

EDN[®]

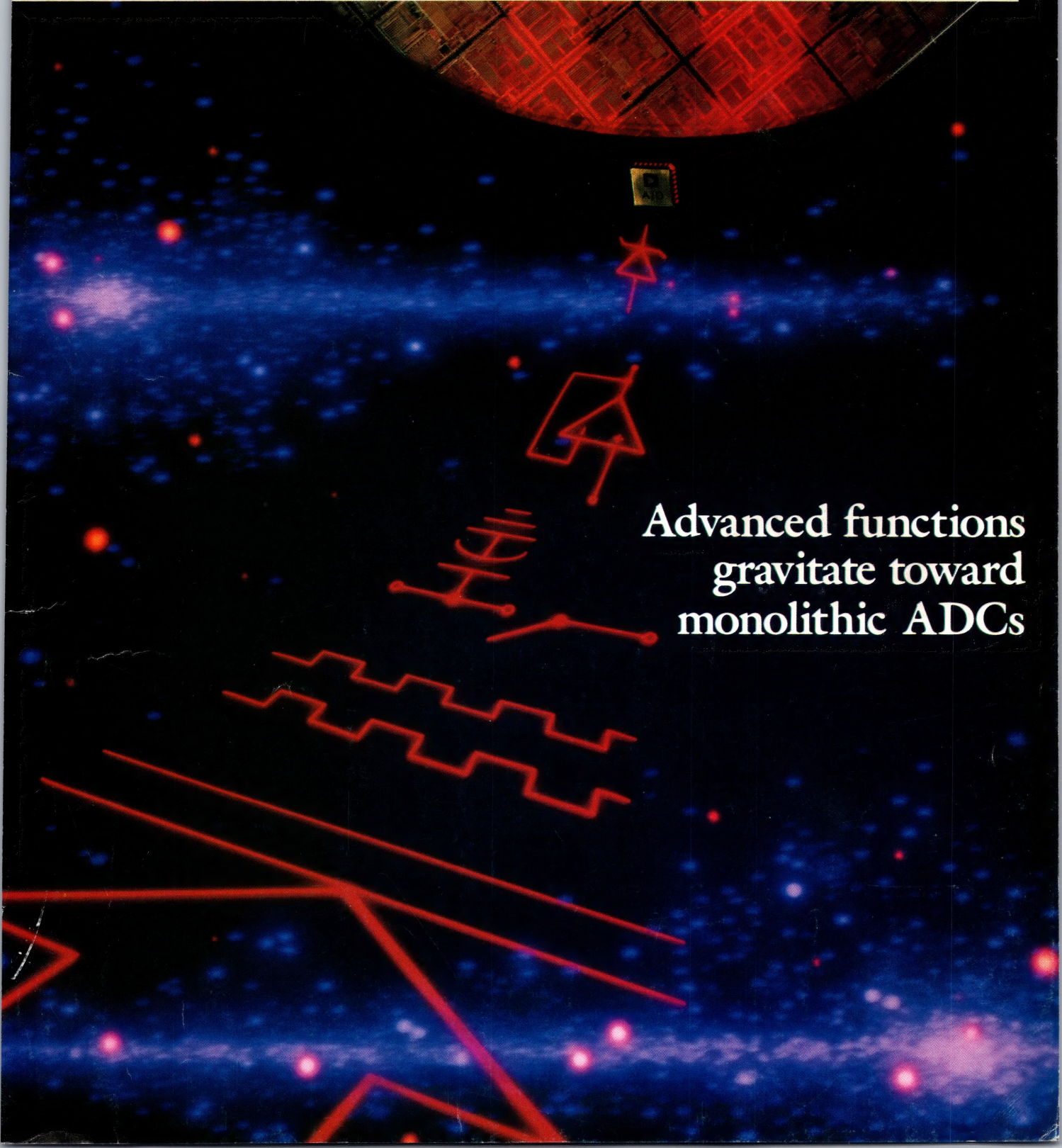
Neural networks
DACs enhance stability
of closed-loop designs

Designer's Guide to
noise analysis—Part 1

Operating systems
for the 80386

MAY 1988

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



Advanced functions
gravitate toward
monolithic ADCs

Finally . . . PRECISION IN SURFACE MOUNT DEVICES

Yes, finally! Precision in a small package.

PMI's precision bipolar analog and CMOS converter product line is now offered in SMD. Write for our SMD brochure which lists the availability of 65 devices in various surface mount packages.

PMI's precision SMDs are available in commercial and industrial temperature ranges. The surface mount offerings include SO, SOL, LCC, and PLCC versions.

To get your SMD brochure, circle the reader service number or call . . . 1-800-843-1515.

You'll also receive a free copy of our new 1988 Data Book!

Precision Monolithics Inc.

A Bourns Company
Santa Clara, California, USA
408-727-9222

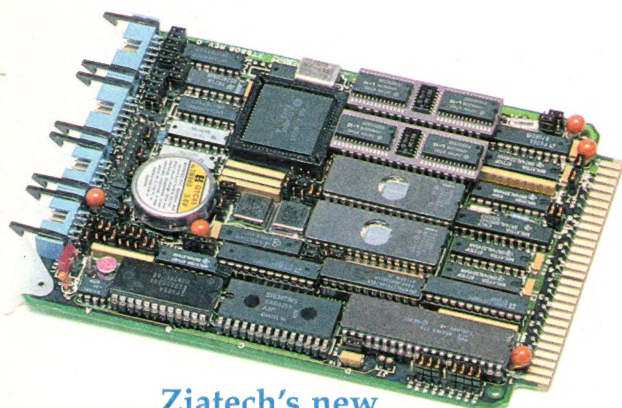
FRANCE: (1) 40 03 35 93; GERMANY: (0711) 22 93-0; BENELUX: (070) 87 54 04; SWITZERLAND: (042) 33 33 33;
UNITED KINGDOM: (0276) 692 392; HONG KONG: (852) 570-2171; JAPAN: (03) 260-1411; ARGENTINA: (46) 5776/0628/0864/2214;
AUSTRALIA: (02) 439-4655; AUSTRIA: (0222) 43 26 39; DENMARK: (02) 98 63 33; FINLAND: (90) 565 38 77; INDIA: 641 7902;
ISRAEL: (23) 924 09 25; ITALY: (02) 569 57 46; KOREA: (02) 244-7492; NORWAY: (06) 83 20 00; SINGAPORE: (65) 339 331;
SPAIN: (91) 405 42 13; SWEDEN: (08) 768 05 60; TAIWAN: (02) 752 2200; YUGOSLAVIA: (041) 42 37 46

CIRCLE NO 119

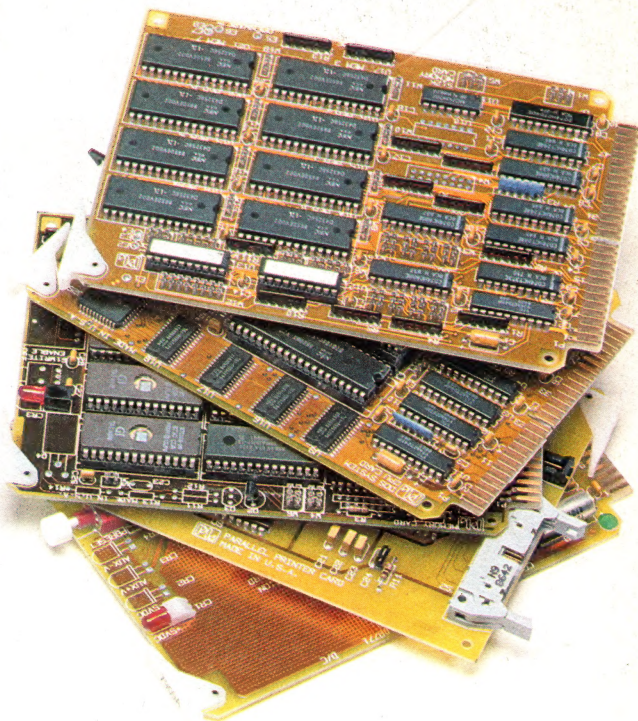


The precision solution.

Less is More.



Ziatech's new
STD Bus ZT 8809
Single Board System
for OEM applications.



Another manufacturer's
"function-per-board"
STD Bus card set
with equivalent capability.

- **PERFORMANCE** (NEC V20 at 8 MHz clock speed)
- **ON-BOARD MEMORY** (520K)
- **IBM PC HARDWARE COMPATIBILITY**
- **ON-BOARD I/O** (2 serial: COM1, COM2; 1 Centronics: LPT1)
- **DEVELOPMENT CAPABILITY** (industry acclaimed Virtual System Console)
- **OPERATING SYSTEM OPTIONS** (STD DOS, VRTX, Multi-DOS, and more)
- **COMPACTNESS** (one board implementation)
- **RELIABILITY** (fewer connectors, components, boards)
- **VALUE** (Ziatech's single board system is \$630 less than the 5-board set pictured above*)

To learn **more** about how **less** (Ziatech's new single board system) is **more** (when compared to the 5-board set pictured above), call Ziatech at 805-541-0488. We'll send you a detailed comparison and all the technical data you'll need.



3433 Roberto Court
San Luis Obispo, California 93401
ITT Telex 4992316
Fax (805) 541-5088
Telephone (805) 541-0488



WHY VTC? ASK THE VME CONSORTIUM.

"For a bunch of companies that don't always agree on everything, we sure were unanimous on VTC."

The VME Consortium needed an economical, yet highly functional VME bus interface chip, to minimize design time . . . and to help raise the VME standard to higher levels.

"We looked at the leading suppliers," said Joe Ramunni, consortium chairman (and president of Mizar), "and VTC came out on top. Their CMOS standard-cell ASIC approach gave us the high drive capability we needed, optimized for bus interfacing. And, it proved much more cost-effective, with higher performance, than gate array technology."

The VME Consortium is made up of such firms as Plessey Microsystems, Omnibyte Corporation, Mizar Inc., Ironics Inc., Heurikon Corporation, Matrix Corporation, and Clearpoint Inc., among others. What did they look for in a supplier?

"We needed a credible business partner," said Ramunni, "with a proven track record, who could provide a turnkey package . . . both design and fab. A supplier that could produce in quantity, and provide technical support to the market at large.

"We also needed a firm with an international marketing structure, because we expect this chip to be the de facto standard worldwide.

"But, we needed *people* we could work with, too. VTC had the right 'comfort factor'."

Jack Regula, consortium technical director (and VP-R&D, Ironics) added: "Our requirements for high speed, high gate-count, low power consumption, and VME bus drive capability were all met well with VTC's 1-micron CMOS standard cell library. And we were extremely impressed with VTC's facilities, its people, and its customer list."

In the future, the VME bus chip (VIC) will become a standard cell within VTC's CMOS library, to allow customers to further customize the chip.

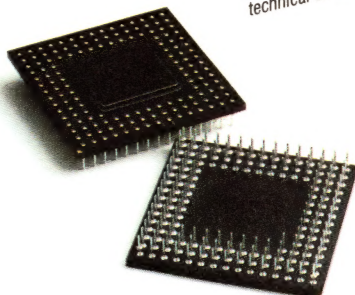
Shouldn't you be getting to know VTC, too? You'll be in good company when you do. Call or write us today, and we'll send you our short-form product catalog, which describes our product offerings in linear signal processing, high-speed CMOS logic, mass storage ICs, bipolar ASIC, and CMOS ASIC.

VTC Incorporated, 2401 East 86th Street, Bloomington, MN 55420.
(In Minnesota, 612/851-5200.) Telex 857113.

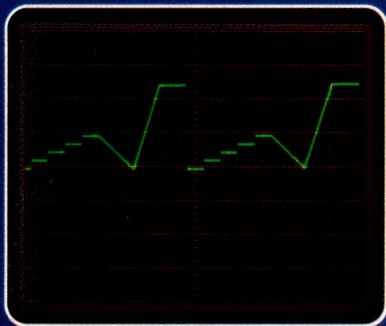
CALL 1-800-VTC-VLSI



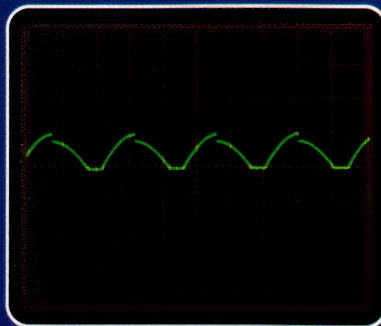
Joseph Ramunni, chairman (left), and Jack Regula, technical director, VME Technology Consortium.



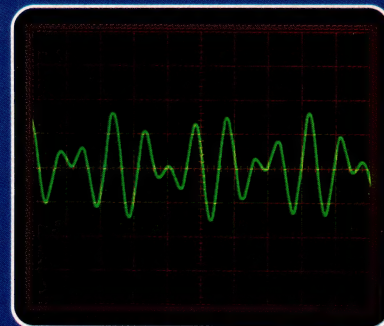
VTC Incorporated
Performance, Pure & Simple™



**Vibration analysis
with stop and hold.**



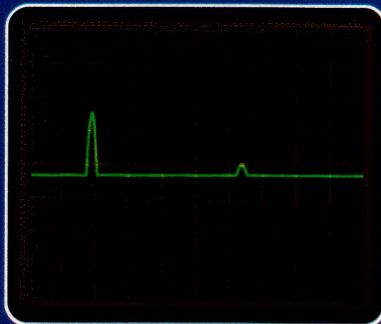
**Complex waveforms
for servo drives.**



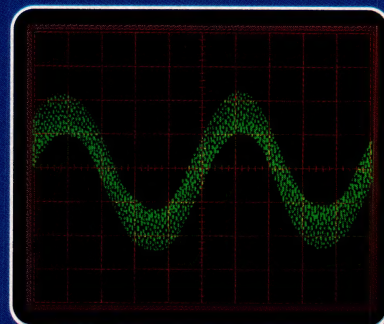
**Dual tones for
telephone testing.**



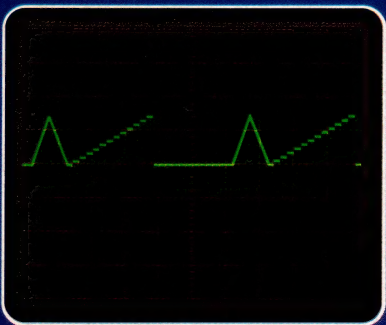
**EKG and hemodynamic
waveforms.**



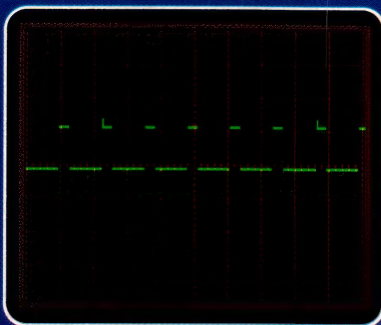
**Radar/sonar envelope
simulation.**



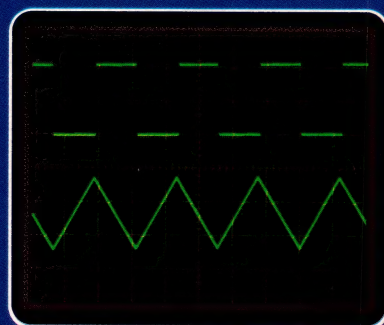
**Noise added to
any waveform.**



**A/D, amplifier development
and calibration.**



**Digital testing and
troubleshooting.**

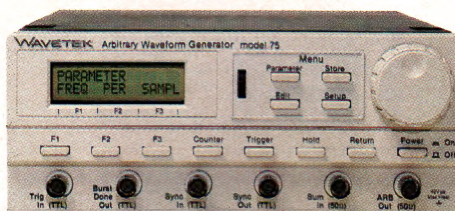


**Standard waves at
the push of a button.**

We've been making waves for 25 years. Now it's your turn.

A quarter-century ago, Wavetek brought you the first waveforms produced by a solid-state function generator. Now our Model 75 Arbitrary Waveform/Function Generator puts you in control.

Model 75 lets you generate waveforms without entering x/y coordinates. Thumbtack and rubberband modes allow easy development and editing of any waveform. There are also nine standard functions which you can use at the push of a button.

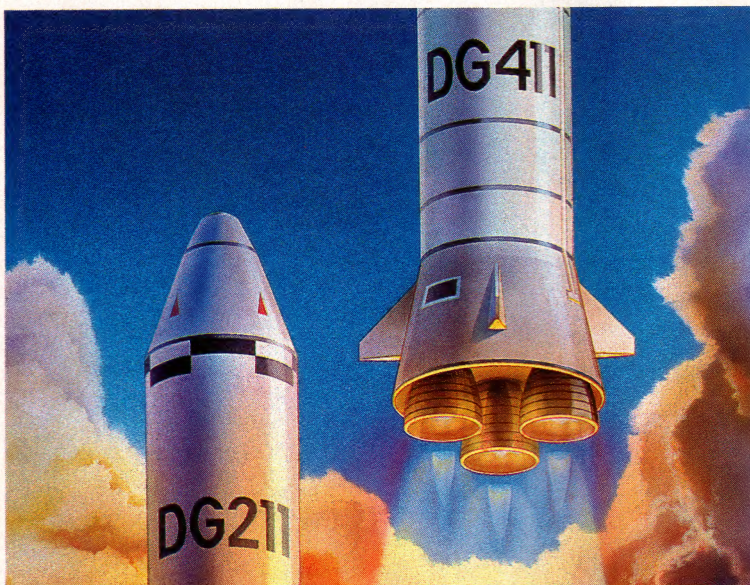


Waveforms are stored in nonvolatile memory, with more than 4,000 vertical points and 8,000 horizontal points of resolution. They can be played back at any rate, up to 500ns per point.

By linking two or more Model 75's together, you can superimpose waveforms to introduce phase displacement or other special effects. And at the low price, you might want to buy several.

For literature or to arrange an amazing demonstration, call or write Wavetek San Diego, Inc., P.O. Box 85265, San Diego, CA 92138. Phone (619) 279-2200; TWX (910) 335-2007.

330,000 X Performance Booster



Switch to the next generation with Siliconix' new silicon-gate DG400 family of analog switches.

Boost performance with lower ON-resistance, less leakage current and faster switching!

The next generation DG411/12/13 series of CMOS quad analog switches combine high performance, precision and low power. Previous technologies have forced the trade-offs of speed for low power, or ON-resistance for leakage. But the DG400 family lets you maximize all these parameters.

Next generation performance is only the beginning. Siliconix' new 44 V silicon-gate CMOS technology is more rugged! 2500 V (min.) ESP (Electro Static Discharge Protection) meets category B of MIL-STD 883B, method 3015.2 for your toughest reliability needs.

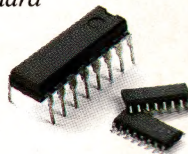
Quad Analog Switch
Performance Comparison

DG211		DG411
1000 ns	Switching Speed	175 ns
20.4 mW	Power Dissipation	35 μ W
5 nA	Leakage	250 pA
175 Ω	On Resistance	35 Ω
1	Normalized Performance Product	330,000

The DG411 family is optimized for minimum charge injection and for TTL-compatibility: Either unipolar 12 V supply or split supply operation.

◀ The performance product, $r_{DS(ON)} \times I_{S(ON)} \times t_{ON} \times PD$, indicates that the DG411 is 330,000 times better than the industry standard DG211.

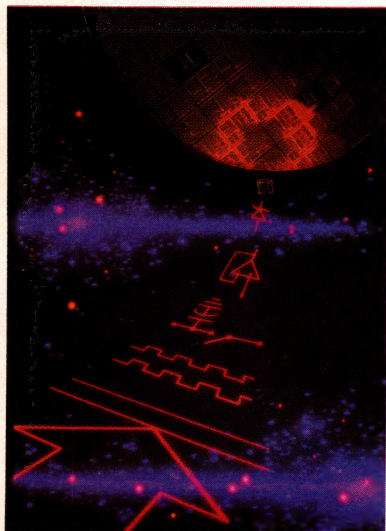
Get a 330,000 X performance boost! Call Siliconix at 1 (800) 554-5565 ext. 933 for a free DG411 sample and Design Kit.



Siliconix
incorporated

2201 Laurelwood Road, Santa Clara, CA 95054

© 1988 Siliconix



On the cover: A/D-converter manufacturers are placing complex, high-speed designs on monolithic chips. And as architectural innovation rolls on, monolithic ADCs will continue to make quantum leaps in performance. See pg 116. (Photo courtesy Analog Devices)

DESIGN FEATURES

Special Report: Monolithic high-resolution ADCs 116

Because ADC improvements will now be driven by architectural changes, you can expect to see phenomenal gains in these chips' performance in the near future.—*David Shear, Regional Editor*

Technology Feature: Data transformation explains the basics of neural networks 138

Neural networks are best at solving problems for which no algorithm exists or for which an algorithmic solution is too slow.—*Doug Conner, Regional Editor*

Designer's Guide to noise analysis—Part 1 153

You can use a systematic analysis technique to determine the noise contributions of the individual elements in an electronic system, no matter how complex it is. This article, part 1 of a 2-part series, describes the noise-analysis technique.—*Peter Fazekas, ILC Data Device Corp*

Precision DACs enhance the stability of closed-loop designs 169

Closed-loop designs oftentimes require the use of DACs that have monotonic response and data readback. This combination is now available in off-the-shelf ICs; thus you'll find it simpler to design stable control loops with 16 bits of resolution and monotonicity.—*Damien McCartney and Mike Curtin, Analog Devices, BV*

Microcontrollers simplify the design of X-Y plotters 181

Modern μ controllers have reduced the amount of circuitry needed for a plotter controller to a single chip and a few motor-drive components.—*Marc Birnkrant and Steve Beckwith, NEC Electronics Inc*

Lithium cells keep CMOS RAM alive during line outages 191

The advent of CMOS RAM has lowered typical memory-backup power requirements to 2 to 3 μ A at 2.0V, even for memories of 1M bits or larger, and now lithium batteries are feasible for such applications.—*Nicolas Muller and Henry Uebelhart, Renata, and Jack F Swartz, International Power Sources*

Continued on page 7

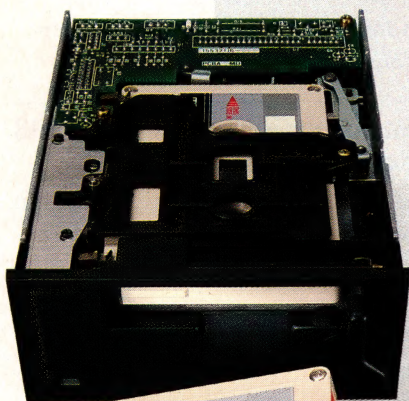


VBPA ABP



EDN® (ISSN 0012-7515) is published 38 times a year (biweekly with 1 additional issue a month) by Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M McDermott, President; Frank Sibley, Electronics/Computer Group Vice President; Jerry D Neth, Vice President/Publishing Operations; J J Walsh, Financial Vice President/Magazine Division; Thomas J Dellamaria, Vice President/Production and Manufacturing. Circulation records are maintained at Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5191. Telephone: (303) 388-4511. Second-class postage paid at Denver, CO 80206-5191 and additional mailing offices. POSTMASTER: Send address corrections to EDN® at the Denver address. EDN® copyright 1988 by Reed Publishing USA; Saul Goldweitz, Chairman; Ronald G Segel, President and Chief Executive Officer; Robert L Krakoff, Executive Vice President; William M Platt, Senior Vice President. Annual subscription rates for nonqualified people: USA, \$100/year; Canada/Mexico, \$115/year; Europe air mail, \$135/year; all other nations, \$135/year for surface mail and \$210/year for air mail. Except for special issues where price changes are indicated, single copies of regular issues are available for \$6, \$8, and \$10 (USA, Canada/Mexico, and foreign). Please address all subscription mail to Eric Schmierer, 44 Cook Street, Denver, CO 80206-5191.

A 155MB 3.5" Format Cassette Data Streamer?



MT-2ST/N50



Yes, 155MB on the TEAC MT-2ST/N50. In a data streamer the size of a standard 3.5" microfloppy disk drive—including SCSI interface. With backup under software control for everything from a single file to an entire hard disk. And read-after-write data verification with sophisticated error correction for the highest data integrity.

A surprising extra: full media compatibility. So that a backup cassette made on one data streamer can be read on any other. This makes data cassettes an ideal means of exchanging or distributing large volumes of data.

Less surprising is the fact that the few Japanese computer manufacturers who haven't already adopted the MT-2ST/N50 are actively considering it. There just isn't any comparable alternative... not in size, capacity, or compatibility. And there probably won't be, until we finalize a second-source licensing agreement!

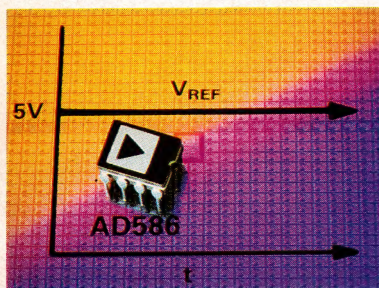
TEAC TEAC CORPORATION

3-7-3 NAKA-CHO,
MUSASHINO, TOKYO, JAPAN
TEL: (0422) 53-1111
TLX: 2822451
FAX: (0422) 55-2554

For Memories You'll Be Glad To Have

■ **Hong Kong**, Nissei Sangyo Co., Ltd. Hong Kong Branch Tel: 3-343441-6; KARIN ELECTRONIC SUPPLIES CO., LTD. Tel: 3-898252 ■ **Singapore**, Nissei Sangyo Pte. Ltd. Tel: 65-7372011 ■ **New Zealand**, Northrop Instruments & Systems Ltd. Tel: 856-658 ■ **Australia**, AWA TECHNOLOGY GROUP Tel: 02 888 9000 ■ **Indonesia**, CHUGAI BOYEKI CO., LTD. Tel: 370824 ■ **Philippines**, COMPEX INTERNATIONAL INC. Tel: 213020 ■ **India**, Priya Electronics & Chemicals Limited Tel: 2863611 ■ **Kuwait**, Bader Al Mulla & Brothers Co. W.L.L. Tel: 2423250 ■ **United Kingdom**, TEKDATA LIMITED Tel: 0782 813631 ■ **F.R. Germany**, nbn Elektronik GmbH Tel: 08152/390 ■ **Austria**, nbn Elektronik GmbH Tel: 04762/5444 ■ **Netherlands**, SIMAC ELECTRONICS B.V. Tel: 040-582911 ■ **Belgium & Luxembourg**, SIMAC ELECTRONICS SPRL/PVBA Tel: 02-219.24.53 ■ **France**, TEKELEC AIRTRONIC S.A. Tel: (1) 4534-75-35 ■ **Italy**, A.E.S.S.E. S.p.A. Tel: 02-54.64.741-2-3 ■ **Spain**, ATAIO Instrumentos S.A. Tel: 733 05 62 ■ **Switzerland**, WENGER PERIPHERALS AG Tel: 01/830 75 55 ■ **Denmark**, Dansk Binær Teknik A/S Tel: 03-662020 ■ **Sweden**, MACROTEK AB Tel: 08-733 02 20 ■ **Norway**, SCANTELE AS Tel: (2) 65 69 20 ■ **Finland**, INSTRUMENTARIUM ELEKTRONIIKKA Tel: 0-5284350

* If no distributor listed above is in your area, please contact us directly for further details about our products.



Advances in voltage-reference-circuit performance give your applications the high accuracy and stability they require (pg 73).

EDN magazine now offers Express Request, a convenient way to retrieve product information by phone. See the Reader Service Card in the front for details on how to use this free service.

Express Request

TECHNOLOGY UPDATE

OS designers consign much of 386's power to writers of applications programs 61

The designers of the 32-bit 80386 μ P packed the device with so many built-in hardware features to support complex multitasking operating systems that no operating-system designer has yet made use of them all.—*Charles H Small, Associate Editor*

Improved voltage-reference circuits satisfy high accuracy and stability needs 73

In the last few years, reference manufacturers have markedly improved device performance. When it comes to accuracy, stability, and thermal drift specifications, today's IC references have truly impressive figures.—*Tom Ormond, Senior Editor*

PRODUCT UPDATE

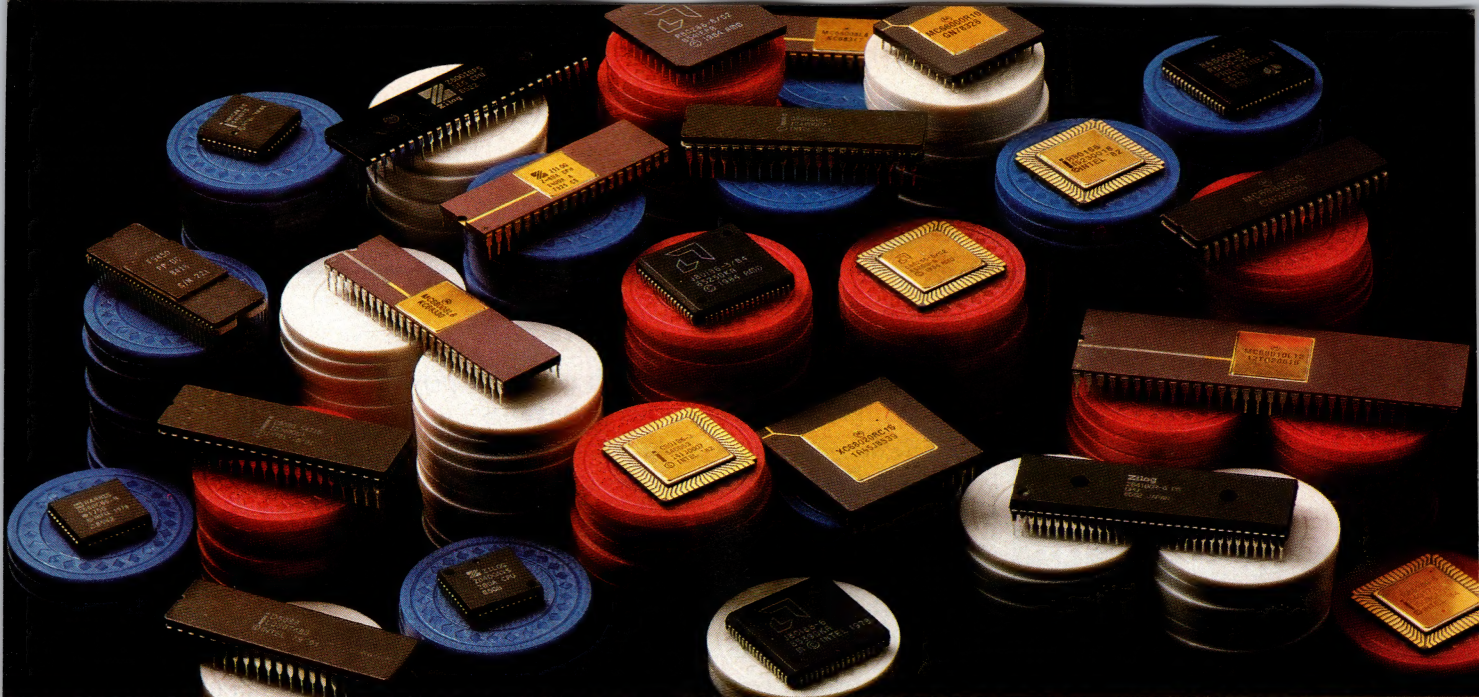
PC-based CAE software	87
CMOS flash EPROMs	88
Mid-sized LCD controller	91
200M-sample/sec 8-bit A/D converter	94

DESIGN IDEAS

Compute square root of bipolar magnitudes	203
Counter controls its own clock frequency	205
Reduce ac-coupled flip-flop's dissipation	207
Swept amplitudes enhance signal generator	207
Alterable code enhances instructions	210

Continued on page 9

Cahners Publishing Company, A Division of Reed Publishing USA ☐ Specialized Business Magazines for Building & Construction ☐ Manufacturing ☐ Foodservice & Lodging ☐ Electronics & Computers ☐ Interior Design ☐ Printing ☐ Publishing ☐ Industrial Research & Technology ☐ Health Care ☐ and Entertainment. Specialized Consumer Magazines: ☐ American Baby ☐ and Modern Bride.



TEK'S 1241 MICRO ANALYSIS SYSTEM REALLY STACKS THE CHIPS IN YOUR FAVOR!

Tek's 1241 microprocessor analysis system includes the Tek 1241 Logic Analyzer. The micro support package of your choosing. Plus performance analysis, storage and communications options. At a new low price. If you're looking for a system to minimize your risk and maximize your return, this is the package you can bet on.

It's proven. The 1241 is known and accepted worldwide as the best of the leading

logic analyzers.

It supports more than 45 microprocessors, microcontrollers and digital signal processors. That's more than any other logic analyzer.

It comes with a specialist.

Tek's dedicated logic analysis sales and applications engineers give you expert support whenever you need it.

It's the best deal on the table. For immediate value and long-term practicality, nothing else can touch it.

Call us. Talk to your local Tek sales representative, or call 1-800-245-2036 for more information about the total Tek 1241 package.



CIRCLE NO 159

Tektronix
COMMITTED TO EXCELLENCE

VP/Publisher
F Warren Dickson

VP/Associate Publisher/Editorial Director
Roy Forsberg

Editor
Jonathan Titus

Managing Editor
John S Haystead

Assistant Managing Editor
Joan Morrow

Special Projects
Gary Legg

Home Office Editorial Staff
275 Washington St, Newton, MA 02158
(617) 964-3030

Tom Ormond, *Senior Editor*
Deborah Asbrand, *Associate Editor*
Joanne Clay, *Associate Editor*
Tarlton Fleming, *Associate Editor*
John A Gallant, *Associate Editor*
Clare Mansfield, *Associate Editor*
Dave Pryce, *Associate Editor*
Cynthia B Rettig, *Associate Editor*
Charles Small, *Associate Editor*
Dan Strassberg, *Associate Editor*
Chris Terry, *Associate Editor*
Ron Gilbert, *Staff Editor*
Valerie Lauzon, *Staff Editor*
Helen McElwee, *Staff Editor*
Steven Paul, *Senior Production Editor*

Editorial Field Offices

Margery S Conner, *Regional Editor*
Los Osos, CA: (805) 528-0833

Doug Conner, *Regional Editor*
Los Osos, CA: (805) 528-0865

Bob Cushman, *Special Features Editor*
Port Washington, NY: (516) 944-6524

Steven H Leibson, *Regional Editor*
Boulder, CO: (303) 494-2233

J D Mosley, *Regional Editor*
Arlington, TX: (817) 465-4961

Richard A Quinnett, *Regional Editor*
San Jose, CA: (408) 296-0868

David Shear, *Regional Editor*
San Jose, CA: (408) 997-5452

Maury Wright, *Regional Editor*
San Diego, CA: (619) 748-6785

Peter Harold, *European Editor*
0603-630782
(St Francis House, Queens Rd,
Norwich, Norfolk NR1 3PN, UK)

Contributing Editors
Robert Pease, Bob Peterson,
Don Powers, Bill Travis

Editorial Services
Kathy Leonard, *Office Manager*
Loretta Curcio, Nancy Weiland,
Sharon Gildea

Art Staff
Kathleen Ruhl, *Art Director*
Ken Racicot, *Assistant Art Director*
Chin-Soo Chung, *Graphic Designer*
Cathy Filipski, *Graphic Designer*

Production/Manufacturing Staff
William Tomaselli, *Production Supervisor*
Donna Pono, *Production Manager*
Andrew A Jantz, *Production Assistant*
Linda Lepordo, *Production Assistant*
Diane Malone, *Composition*

Graphics Director
Norman Graf

VP/Production/Manufacturing
Wayne Hulitzky

Director of Production/Manufacturing
John R Sanders

Director of Research
Deborah Virtue

Marketing Communications
Janice Molinari, *Manager*
Jennifer Ware, *Communications Manager*
Anne Foley, *Promotion Assistant*

EDITORIAL

53

Recently, the IEEE took action on behalf of underpaid engineers. That's a step in the right direction, but the IEEE hasn't addressed the larger problem: Most people don't even know what an engineer is or what one does.

NEW PRODUCTS

Integrated Circuits	215
Components & Power Supplies	231
Computers & Peripherals	244
Test & Measurement Instruments	256
CAE & Software Development Tools	268

PROFESSIONAL ISSUES

297

Dick Burwen: mixing a love of engineering with a passion for hi-fi.
—Deborah Asbrand, *Associate Editor*

LOOKING AHEAD

313

US position-sensor market to grow steadily through '91...Consider associated costs of nonimpact printers.

DEPARTMENTS

News Breaks	21
News Breaks International	24
Signals & Noise	32
Calendar	42
Readers' Choice	100
Leadtime Index	108
Literature	286
Business/Corporate Staff	294
Career Opportunities	304
Advertisers Index	311

Odds are 50-50
your perfect ASIC is a
perfect dud the first time
you plug it in.



That's why Mentor Graphics lets you combine ASIC and board circuitry in a single simulation.

Trouble in ASIC paradise.

The big day has arrived.

Your first gate array is back from the foundry. With high expectations, you plug it into your board and power up.

It doesn't work.

Don't feel alone. Over 50% of ASICs aren't operational when first installed in their target system. Even though 95% pass their foundry tests with flying colors.

An immediate solution.

Mentor Graphics shifts these even odds heavily in your favor with our QuickSim™ logic simulator, which lets you simulate both your ASIC and board circuitry in a single run.

With QuickSim, you not only track the internal operations of your ASIC circuitry, but also its transactions with the system at large. If there's a problem, you see precisely where it's located, either inside or outside your ASIC. All in a single, interactive simulation environment, where you can view and graphically "probe" the circuitry created by our NETED™ schematic editor.

Check out our libraries.

Library support is an ideal benchmark to gauge the true worth of an electronic design automation system. The more diverse and plenti-

ful the component modeling libraries, the greater the design capability. It's as simple as that.

By this simple, yet decisive measure, Mentor Graphics brings you unequaled design capability. While other EDA vendors scurry to produce their own ASIC libraries (with little guarantee of accuracy), more ASIC vendors put their libraries on Mentor Graphics workstations than any other. And in most cases, we're the first workstation supported, which means you have the first shot at exploiting new chip technologies.

With Mentor Graphics, you get a breadth of LSI and VLSI component models, both hardware and software based. All of which can be mixed with ASICs in a single simulation that cuts your run time to an absolute minimum.

To be continued.

So much for the present. We're already developing new systems EDA tools that will extend to every dimension of electronic product development. From high-level systems descriptions to CASE. It's what our customers expect. It's what we'll deliver.

It's all part of a vision unique to Mentor Graphics, the leader in electronic design automation. Let us show you where this vision can take you.

Call us toll-free for an overview brochure and the number of your nearest sales office.

Phone 1-800-547-7390
(in Oregon call 284-7357).



Sydney, Australia; Phone 612-959-5488
Mississauga, Ontario; Phone 416-279-9060
Nepean, Ontario; Phone 613-828-7527
Paris, France; Phone 33-1-39-46-9604
Munich, West Germany; Phone 49-57096-0
Neu-Isenburg, West Germany; Phone 49-6102-25092-94
Hong Kong; Phone 852-566-5113
Givatayim 53583, Israel; Phone 972-777-719
Milan, Italy; Phone 39-824-4161
Asia-Pacific Headquarters, Tokyo, Japan; Phone 813-505-4800
Tokyo, Japan; Phone 813-589-2820
Osaka, Japan; Phone 816-308-3731
Seoul, Korea; Phone 822-548-6333
Spanga, Sweden; Phone 468-750-5540
Zurich, Switzerland; Phone 411-302-64-00
Taipei, Taiwan; Phone 886-2-776-2032
Haltweg, Netherlands; Phone 31-2907-7115
Singapore; Phone 65-779-1111
Bracknell, England; Phone 44-344-482848
Livingston Scotland; Phone 44-506-412222
Middle East, Far East, Asia, South America; Phone 503-626-7000
Helsinki, Finland; Phone 358-0-45571
Madrid, Spain; Phone 34-1-754-3001

Mentor Graphics®

Your ideas. Our Experience.

(Forward Thinking, Re

It takes more than desk-changing for two companies to merge. They need to have a shared vision of the world and the future.

With AMD and MMI, the calling was clear. To produce advanced programmable logic devices for a wide range of needs. To lower system costs. To develop higher performance designs. And to get your products to market as soon as possible.

We're delivering on this promise of the future in myriad ways. With a product line that doesn't stop halfway. With the first 10ns parts for designs where speed's important. In CMOS, we have the broad-

est line of parts, including the industry standard, C22V10. And for high density, no one can beat our programmable gate arrays. We've got the best selection of PAL[®] parts around. (And no one sells more to the military.)

We're bringing new meaning to the term "product availability." Our combined manufacturing capacities mean we have more PAL chips coming out of our pipeline. Ready to be put into yours.

More Field Application Engineers give you more answers to get projects up and running.

Because it's impossible to create

sponsive, Meticulous)²

great designs without great software, we also offer PALASM[®] software, the industry standard. We're investing heavily to keep PALASM as current as our hardware.

With the best network of distributors, we can now offer a whole new concept in distributor support: TestPro Centers. Now you can speed through programming and testing at authorized centers.

Just bring your logic pattern to your closest TestPro Center. They'll program and they'll test the parts to factory quality

standards. Relieving you of the burden of test vector generation.

And we'll always be here with immediate and expert help in getting your design moving. All you have to do is get in touch.

One try and you'll be sharing our vision, too.

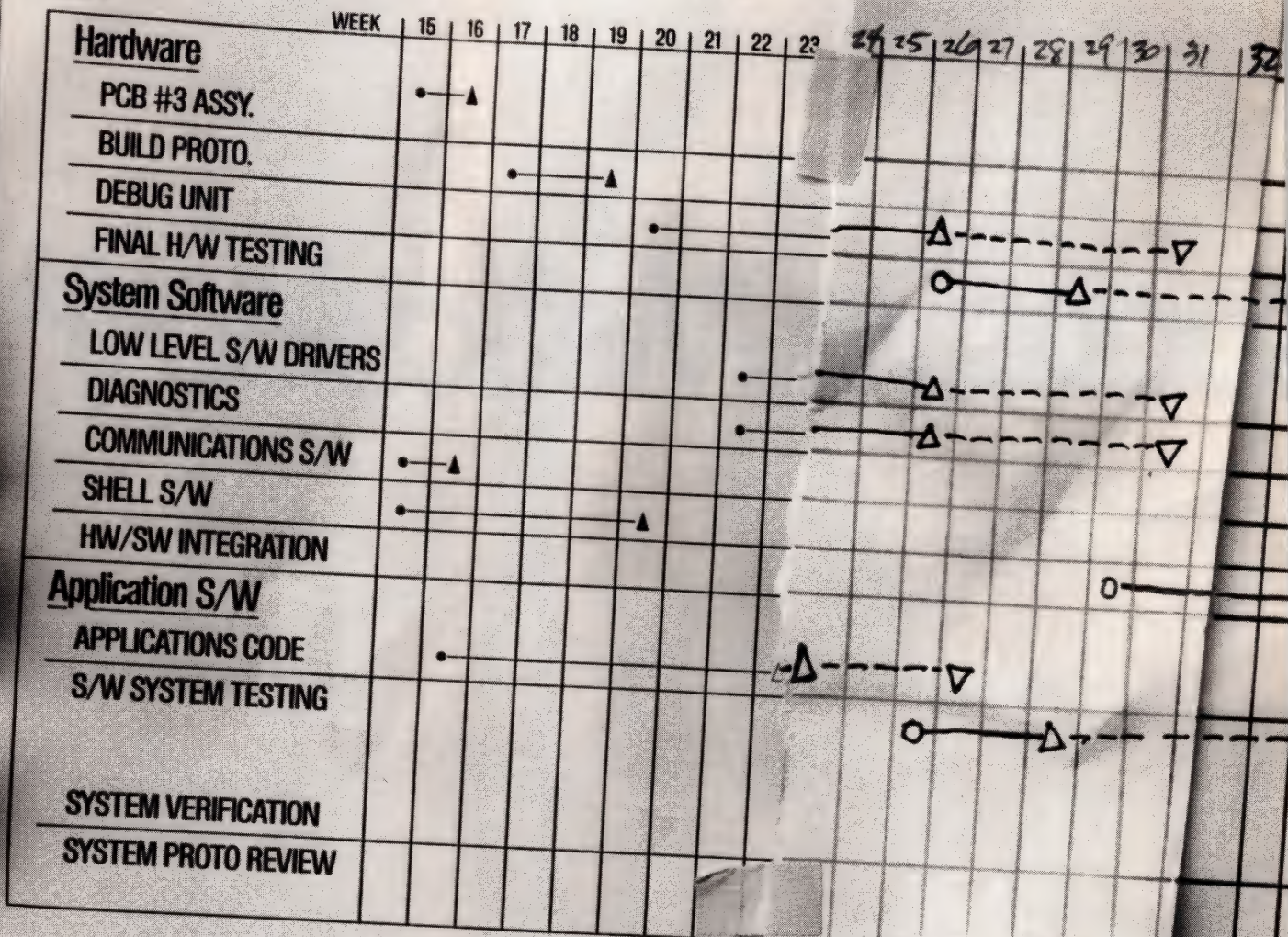
Advanced Micro Devices 
Monolithic Memories 

For more information, write "PALS" on your letterhead and mail to: P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS, United Kingdom.
Bruxelles (022) 771 91 42 • Hannover area (0511) 73 60 85 • Hong Kong (5) 8654525 • London area (04862) 22121 • Manchester area (0925) 828008 • Milano (02) 3533241
München (089) 41 14-0 • Osaka (06) 243-3250 • Paris (1) 49 75 10 10 • Seoul (02) 784-7598 • Singapore (65) 225 7544 • Stockholm (08) 733 03 50 • Stuttgart (0711) 62 33 77
Taiwan (02) 7122066 • Tokyo (03) 345-8241 • Latin America, Fort Lauderdale, Florida/U.S.A. Tel: (305) 484-8600 Tlx: (510) 955-4261 amd fti

PAL and PALASM are registered trademarks of Monolithic Memories, Inc., a wholly owned subsidiary of Advanced Micro Devices, Inc. © 1988 Advanced Micro Devices, Inc.

It's your choice.

PRODUCT DEVELOPMENT SCHEDULE PAGE 2



Let's face it. Slipped development schedules and budget overruns can mean lost opportunities. Yet many traps that seriously delay a development schedule are quite complex, especially when they are compounded by problems that arise in cross development work.

Like not knowing whether the errors you are getting from your prototype processor are real. Or losing bugs in the cracks between your development system and the prototype.

Fortunately, the answer to these complex problems is simpler than you might think. Because now Applied Microsystems offers what we call performance packages: complete, fully integrated development solutions, designed to meet your development requirements and to detect even subtle problems quickly.

Performance Packages that Live Up to Their Name.

Each package includes a powerful in-circuit emulator, the only tool that can

successfully bridge the gap between host computer and prototype. With features like complex triggering, reliable memory, built-in target diagnostics, I/O simulation, and special interrupt handling.

And to complement the power of our emulators, we provide software tools that work with a variety of platforms and languages.

Whichever package you choose, you're getting the highest performance

Invest now or pay later.

are designed for any language producing complete Intel OMF information.

A PC-based, in-circuit source level debugger and simulator are closely cou-

remote control and simulation of I/O; plus user-definable windows for viewing registers, stacks and variables

High-speed Symbolic Debugging for Intel, Motorola and Zilog Microprocessors

Our VALIDATE/ES DRIVER package includes easy-to-use (menu-driven and remote control) software that smoothly links the host functions to the ES 1800 emulator. This allows the upload and download of programs, symbol tables and command files.

```

15: for count = 1:count <= 100; count ++
16:
17:   begin f
18:     outcount f
19:     outcount(count)
20:     delay f
21:   end f
22:
23:   test
24:   AX=0000 SP=0000 CS=3020 IP=0000
25:   BX=0000 BP=0000 DS=1007 FL=0000 = 0D 00 00 00 00 00 00 00
26:   CX=0000 SI=0000 SS=3020
27:   DX=0000 DI=0000 ES=0000
28:   *asm 12
29:
30:   12: many f
31:   2FD30000 56   PUSH   SI
32:   2FD30001 57   PUSH   DI
33:   2FD30002 55   PUSH   BP
34:   2FD30003 8BEC  MOV     BPSP

```

pled with our ES 1800 emulator. You can use commands to examine variables on the fly, check contents of registers, and determine current position in code. And real-time trace is displayed as source level statements, machine instructions or bus cycles.

The packages also include a logic state analyzer probe, and provide up to 2 Megabytes of overlay memory plus full protect mode support for the 80286.

Source Level Debugging for Motorola Microprocessors

The window-oriented VALIDATE/XEL package combines our XEL source-level debugger, a simulator and the MCC68K compiler with our ES 1800

```

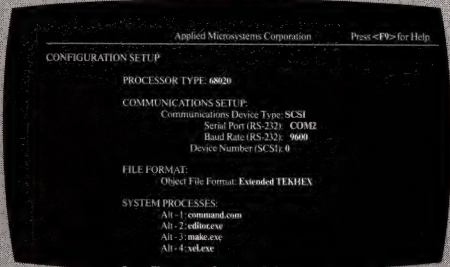
1 count 0
2 ptr 0
3 ptr 0
4 [apexcount] 0

CODE
13 for i = 0, ptr = tape; i < TAPE_SIZE; i ++
14   ptr ++ = 70
15   state = 1
16   count = 0
17
18   ptr = &apexcount
19   do
20     switch (state)
21     case 1
22       if (ptr == 70)

```

emulator. The package also includes a logic state analyzer probe and our well-known SCSI interface option, that significantly decreases download time.

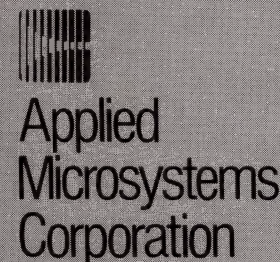
In addition to up to 2 Megabytes of overlay memory, you get target control from your source code; powerful "C" language macros for code patching,



Also included are a logic state analyzer probe; the SCSI option for increasing download speeds by up to 30 times; plus up to 2 Megabytes of overlay memory.

To find out more about 8, 16 or 32-bit development solutions that save money in the long run, write Applied Microsystems Corp., P.O. Box 97002, Redmond, WA 98073-9702. Or call 1-800-426-3925 (In Washington, call 206-882-2000).

In Europe, contact Applied Microsystems Corporation Ltd., Chiltern Court, High Street, Wendover, Aylesbury, Bucks, HP22 6EP, United Kingdom. Call 44-(0)-296-625462.



development tools available.

Source Level Debugging for Intel Microprocessors

Our VALIDATE/Soft-Scope and VALIDATE/Soft-Scope 286 packages

IF YOU STILL THINK
ENOUGH MAXTOR
LET US DRIVE HOME

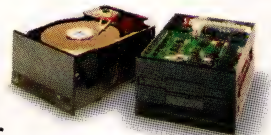


THERE AREN'T DRIVES TO GO AROUND, A SIMPLE POINT.



Maxtor delivers more high-capacity drives than anybody in the industry. At very competitive prices.

More 380MB Winchester drives.
More 760MB
Winchester drives.
More of everything
we make. From our
140MB Winchester to our 800MB
optical drive.



What's more, our subsidiaries Storage Dimensions and U.S. Design deliver production quantities of complete plug-and-play mass storage subsystems for PCs, workstations and minicomputers.

So when you're ready to out-drive the competition, think of the company that out-drives everybody. Maxtor.

Call 800-227-1817 (ext. Maxtor) for the Maxtor sales office or distributor near you.

Maxtor

CIRCLE NO 162



Only HP can put real teeth into faster

Test development and execution speed. We know they're your top priorities. HP BASIC,* combined with our range of controllers and instrumentation, is the answer. Even if you're running on MS™DOS or the UNIX™ operating system. And of course, it's all backed by HP's measurement expertise, and the product reliability you've come to count on from an industry leader.

HP BASIC: Optimized for instrument control.

It's no secret that a critical element of automated instrument control is fast development time. That's where HP BASIC really shines. With power, versatility and ease of use. We invite you to find a better instrument control language.

A few examples:

- Fast program development with interactive editing, syntax checking and the ability to search and replace

strings, or move blocks of code easily.

- Optimized for I/O with advanced constructs to simplify otherwise complex tasks. Interrupts, high speed data transfers, automatic data formatting and branching on events can all be handled easily. Since HP BASIC was designed for instrument control, these capabilities are integral, not tacked on as an afterthought.

- Structured programming lets you make your program modular with independent subprograms which can be re-used in other applications. Constructs like CASE statements, IF-THEN-ELSE, WHILE, REPEAT-UNTIL and LOOP are useful for rapid program development and invaluable for program maintenance.

- Powerful computation lets you take advantage of a full range of matrix manipulations such as multiplication, inversion and scalar operations. HP's complex number implementa-

tion allows for powerful arithmetic operations.

- Graphic capabilities are simple to program, yet powerful. One program statement can draw axes or grids, a second will plot your data, a third will label your plot and a fourth will provide a permanent copy.

HP Controllers: The right horsepower for the job.

Hewlett-Packard provides a wide range of instrument controllers and operating systems to meet your performance needs, allowing you to choose the most cost effective controller for your job.

Just look:

- Personal computers; the HP BASIC Language Processor allows you to use HP BASIC on the world's most prevalent operating system, MS DOS. It's available for the HP VECTRA or the IBM PC-AT.

*Sometimes called Rocky Mountain BASIC or BASIC 5.0.

we never stop
asking

"What if..."

test development.

- Dedicated controllers up to 4 MIPS. HP's Series 300 controllers provide a dedicated, high performance system for maximum I/O throughput.
- HP-UX workstations. HP BASIC will also be available for use in the Series

**Trim more time:
Deal with the pros.**

Our sales, service and support team can get your test up and running when time is of the essence. With over

500 instruments, HP is the recognized industry leader in test and measurement.

**Call HP for
a free video.
1-800-752-0900,
Dept 215R**



300 HP-UX environment. Our implementation combines the ease-of-use and performance of HP BASIC with the full networking, multitasking and windowing capabilities of the UNIX operating system.

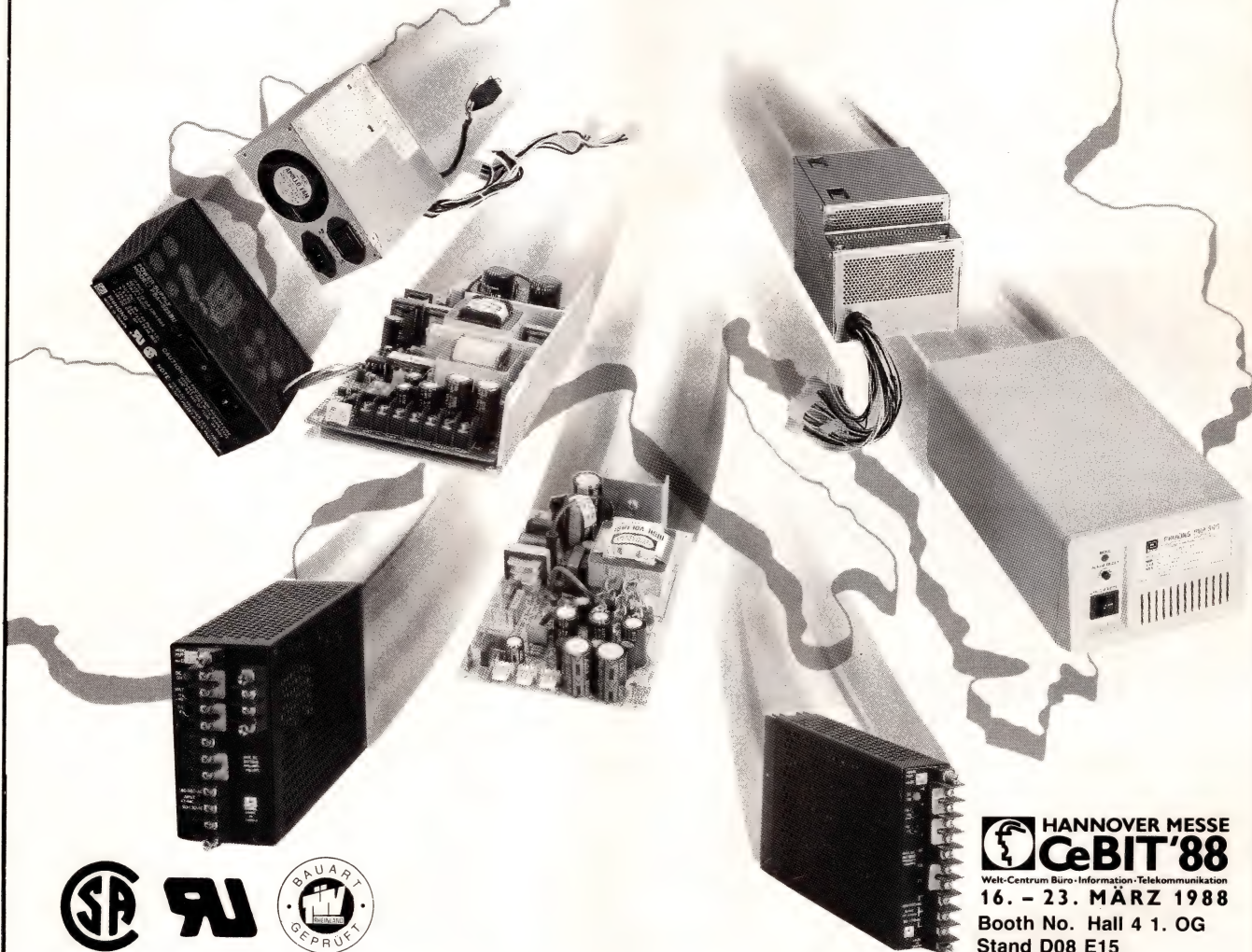
No matter the controller demand, HP makes it in the optimum package.

Ask for our free videotape on HP BASIC or a brochure on HP instrument controllers. Learn how Hewlett-Packard can help you cut test development time significantly. More questions? Contact your local HP rep listed in the white pages.

© 1988 Hewlett-Packard Co. EI 15814/EDN

 **HEWLETT
PACKARD**

Your unlimited power partner-PHIHONG



PHIHONG's 16 years of experience in development & design of continuous power, power supplies, gives its customers an unequalled advantage in meeting their needs switching power supplies, ranging 15 to 300 watts, are available in a variety of styles

and are UL CSA and TUV approved. What makes all this possible is the advanced technology and high quality people and materials available. Next time your need power, we'll be glad to assist.

HANNOVER MESSE
CeBIT'88
 Welt-Centrum Büro-Information-Telekommunikation
16. - 23. MÄRZ 1988
 Booth No. Hall 4 1. OG
 Stand D08 E15



PHIHONG ENTERPRISE CO., LTD.
 TAIWAN PLANT: 27-12 TAYU ST.,
 SANCHUNG CITY, TAIPEI, TAIWAN, R.O.C.
 TELEX: 31182 PHIHONG PHONE: (02) 988-2126
 FAX: 886-2-9817086

PHIHONG U. S. A. INC.
 240 LOS GATOS BLVD LOS GATOS, CA95032
 TEL: (408)395-9222 FAX: (408) 395-3075

NEWS BREAKS

EDITED BY JOANNE CLAY

DIGITAL FILTER CUTS NOISE FROM T1 COMMUNICATIONS LINES

The S3541 digital-filter IC implements the C message-weighted, highpass, and 1-kHz notch filtering required by T1-carrier communications lines installed in the US telephone network. The chip meets all the specifications of Bell Pub #41009 (May 1975) and IEEE standard 743 (1984). It uses digital filtering—which provides manufacturing repeatability, zero temperature drift, and zero drift over time—to solve the noise problem, which is traditionally solved with analog filtering. Gould Inc's Semiconductor Div (Santa Clara, CA, (408) 246-0330) offers the device in a 28-pin DIP for \$17.95 (1000).

—Steven H Leibson

LOGIC ANALYZER EXPANDS FROM 16 TO 64 CHANNELS

If you're looking for test equipment that expands with your needs, consider the Model 1230 logic analyzer from Tektronix (Portland, OR, (800) 245-2036). You can purchase the unit with 16 channels and then add capacity as your needs grow. The basic unit offers a built-in display with RS-170 output, nonvolatile storage for setups, glitch catching, and timing to 100 MHz. Your expansion options include additional data channels in groups of 16 (to a total of 64), a parallel port for dumping screen data to a printer, and a control-I/O port. You can choose the RS-232C or the IEEE-488 (GPIB) interface for remote control. The basic unit costs \$2795; delivery is four weeks. The 16-channel expansion boards cost \$1200 each. Other options begin at \$200; delivery is 10 weeks.—Richard A Quinnell

FULL-FEATURE TIME-INTERVAL COUNTER COSTS \$3850

The SR620 time-interval counter from Stanford Research Systems Inc (Sunnyvale, CA, (408) 744-9040) costs \$3850 and allows you to make frequency, period, rise-time, fall-time, and phase measurements in addition to time-interval measurements. You can measure frequencies from 0.001 Hz to 1.3 GHz and time intervals to 1000 sec. The instrument measures time intervals with 30-psec jitter and 4-psec resolution. You can make phase measurements from 0.001 Hz to 100 MHz with 0.001° resolution. The SR620 provides mean, min, max, and Allan variance statistics on as many as 1 million samples. Measurements are displayed on a digital front panel; alternatively, you can use an oscilloscope to display histograms using the oscilloscope's X-Y inputs. The instrument comes with RS-232C and GPIB interfaces and a Centronics printer port. An optional, oven-stabilized crystal timebase costs \$950.—Doug Conner

COLOR-PALETTE CHIP IS ALTERNATE SOURCE FOR PS/2 GRAPHICS

Available in 35-, 45-, and 80-MHz versions, the VDA-176 color-palette IC from VLSI Design Associates (Campbell, CA, (408) 371-7400) provides a pin-compatible alternative to the IMS-176 from Inmos (Colorado Springs, CO), which is used in IBM's PS/2 computers and on VGA graphics boards. The color-palette chip incorporates a 256x18-bit RAM, three 6-bit D/A converters, and output circuitry capable of driving standard RS-170 video cables. Packaged in a 28-pin DIP, the 35-MHz devices cost \$10 (1000).—Steven H Leibson

25-MHz CACHE CONTROLLER INTERFACES DIRECTLY TO 80386 μ P

The A38152-25 Microcache from Austek (Mountain View, CA, (415) 960-1315) is a speed upgrade of the company's earlier 20-MHz version. The device is a 4-way set-associative controller that supports a 32k-byte zero-wait-state cache memory and has a direct interface to an 80386 μ P and to four 8kx8-bit static RAMs. The A38152-25 comes in an 84-lead PLCC and is available immediately in sample quantities for \$145.—David Shear

NEWS BREAKS

BED-OF-NAILS TEST PROBES HAVE 1-M Ω , 3.8-pF LOADING

The P6511 and P6513 spring-loaded active test probes from Tektronix (Vancouver, WA, (800) 835-9433, ext 170) allow you to obtain high-fidelity waveform data using bed-of-nails fixtures, without loading down critical circuit nodes. The active hybrid probes have a 300-MHz bandwidth, 1-M Ω resistance, 3.8-pF input capacitance, and 50 Ω output impedance. You can mount the probes on 100-mil centers for bed-of-nails and other board-testing applications. The probes cost \$225; delivery is six weeks.—Doug Conner

DIGITAL CELL LIBRARY LETS YOU DESIGN 1.2- μ m CMOS ASICs

Designers of CMOS ASICs can now obtain a 1.2- μ m process and a digital-cell library from International Microelectronic Products (San Jose, CA, (408) 432-9100). The company plans to offer an analog-cell library for the process later this year. The double-layer-metal, double-poly CMOS process allows for system clocks running at as much as 40 MHz and provides typical gate delays of 300 psec. The digital-cell library, DCL 1.2, features 70 cells and includes a RAM, ROM, and PLA compiler. The price of the library is included in the NRE costs of your ASIC design. Typical NRE costs are between \$40,000 and \$100,000.—Richard A Quinnell

PRICE OF 12-BIT A/D CONVERTERS CONTINUES TO DROP

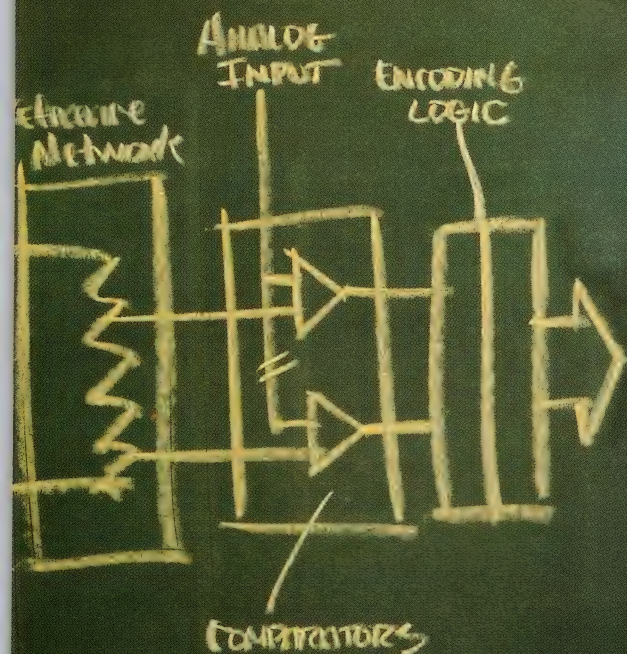
The MAX172 from Maxim Integrated Products (Sunnyvale, CA, (408) 737-7600) is a 12-bit, 10- μ sec CMOS A/D converter that costs just \$10 (1000). The device requires a 5V and -12V or -15V supply; it converts an analog input ranging from 0 to 5V. The result is available as a 12-bit word or two 8-bit words via a parallel 3-state output. An on-chip voltage reference allows a full-scale temperature coefficient of 45 ppm/ $^{\circ}$ C. The MAX172 is packaged in a 24-pin, 0.3-in.-wide DIP or a 24-pin SOIC.—David Shear

OPTICALLY STORED DOCUMENTS ARE LEGALLY ACCEPTABLE

Three years of research by Cohasset Associates Inc (Chicago, IL, (312) 527-1550) has culminated in the book *Legality of Optical Storage*, a 320-page, looseleaf volume edited by Cohasset's president, Robert F Williams. By relating optical-storage methods to microfilm and magnetic storage techniques, the book concludes that a solid legal foundation exists for the use of optically stored documents in court proceedings and regulatory hearings. The book's \$230 price also covers a 1-year subscription to an update service that tracks the incorporation of optical document storage in new laws and regulations.—Steven H Leibson

FLASH EEPROM APPROACHES EPROM STORAGE DENSITY AND COST

Flash EEPROMs offer two advantages over conventional UV EPROMs: onboard programmability and faster program and erase times. Their drawbacks, however, have been lower storage capability and higher cost. The 48F512 flash EEPROM from Seeq Technology Inc (San Jose, CA, (408) 432-7400) reduces these drawbacks with its 512k-bit storage density and \$33 (100) price. The write time is 1 msec/byte; the chip-erase time is 5 sec. The vendor specs the chip's endurance (the number of times the chip can be erased and rewritten) at 100 cycles.—Margery S Conner



THE COMPETITION IS STILL TALKING ABOUT THEIR 10-BIT FLASH ADC

That's right — shipping. For years there's been a lot of talk about monolithic 10-bit ADCs. The talk is over. The TDC1020 is a reality. The world's first monolithic 10-bit flash ADC is available from TRW LSI Products.

And the best news is the performance. It's going to be hard to beat. This truly state-of-the-art flash converter guarantees 10-bit resolution at a 20MSPS conversion rate over both commercial and military temperature ranges. Packaged in a 64-pin DIP, its outstanding features include TTL interface, overflow flag, selectable output formats and guaranteed no missing codes. All you need is a standard $\pm 5V$ power supply and a challenging application.

The TDC1020 can help your equipment achieve the kind of performance

that you've been dreaming about for years. But beyond performance, the TDC1020 in your system will be a real cost and space saver too.

So stop listening to all the talk about 10-bit ADCs. The TDC1020 is here. Now! Try it in your medical imaging, broadcast video, military, process control equipment or any other demanding application.

Call for a full data sheet, pricing and immediate technical assistance. Production quantities are available right now from TRW LSI Products and our national distributors — Hall-Mark and Hamilton/Avnet.

**TRW LSI Products —
bringing the worlds of Data
Acquisition and DSP together.**

WE'RE SHIPPING OURS

TRW LSI Products
P.O. Box 2472
La Jolla, CA 92038
619.457.1000

In Europe, phone:
TRW LSI Products
Munich, 089.7103.124;
Paris, 1.69.82.92.41;
Guildford (U.K.), 0483.302364

In the Orient, phone:
Hong Kong, 3.880629;
Tokyo, 03.234.8891; Taipei, 751.2062;
Seoul, 2.553.0901

© TRW Inc. 1988 — 712A03287

TRW

TRW LSI Products

CIRCLE NO 164

NEWS BREAKS: INTERNATIONAL

STE BUS CARDS IMPLEMENT A LOW-COST, IBM PC-COMPATIBLE TARGET

In addition to providing MDA/CGA-compatible display capabilities, the £195 SPCGA STE Bus card from Arcom Control Systems Ltd (Cambridge, UK, TLX 94016424) includes sockets for as much as 256k bytes of ROM/EPROM or 128k bytes of static RAM. Firmware available for the card allows ROM/EPROM on the SPCGA card to operate as a silicon disk, which appears to the system as the A drive in a normal MS-DOS environment. As a result, you can create a low-cost, 2-card IBM PC-compatible STE Bus target system by adding the company's £345 SCPC88 8088-based CPU card. In this configuration, the CPU card provides the system with as much as 256k bytes of RAM. By selecting from a wide range of STE Bus-compatible I/O and signal-conditioning cards, you can tailor the system for use as an embedded controller in industrial-control applications. Because your target system will be IBM PC compatible, you can develop software for it on your IBM PC.—Peter Harold

LOW-FREQUENCY SPECTRUM ANALYZER HAS VARIETY OF ANALYSIS MODES

Although some of its main application areas lie in the realm of mechanical engineering, the SI-1220 multichannel spectrum analyzer's bandwidth—dc to 50 kHz—makes the instrument suitable for use in designing a variety of low-frequency and audio-frequency electronic systems, such as closed-loop control systems and hi-fi equipment. The analyzer is manufactured by Schlumberger Technologies' instrument division (Farnborough, UK, TLX 858245; in the US: Burlington, MA, (617) 229-4825). It provides two or four input channels, and it can simultaneously measure frequency-response functions between all its channel pairs. In addition, the analyzer has a maximum resolution of 1000 spectral lines, and it allows you to zoom to 1-mHz resolution.

Its optional waveform generator provides continuous or burst-mode stimulation of your system with a variety of standard or user-defined waveforms. The instrument's standard sample memory is 256k samples deep, but you can optionally expand it to a depth of 1M samples. Its analysis features include logarithmic frequency resolution, octave analysis, twin-band analysis, and swept-sine frequency-response analysis. The analyzer's waterfall displays, with optional gray scales (Z-modulation), allow you to highlight system performance. A 2-channel version costs approximately £13,000.—Peter Harold

SINGLE CHIP HOLDS FLOPPY-DISK-DRIVE CONTROLLER CIRCUITRY

The μ PD72068 CMOS chip from NEC integrates all the main functions of a floppy-disk-drive controller. The LSI circuit's die size is 6.33×6.18 mm. According to the Japanese press, engineers can use the chip to reduce the mounting area of floppy-disk-drive components to one-fifth the area of conventional controllers, and can expect to achieve floppy-drive data-transfer rates of 600k bps. The chip dissipates 50 mW while operating and 0.5 mW while on standby. You can obtain samples of the part for ¥5000 (about \$38) each.—Joanne Clay

ASICs OFFER 0.4-NSEC DELAY AND A MAXIMUM OF 129,000 GATES

Toshiba Corp has recently introduced the TCI20G Series master-chip ASICs, which feature a delay time of 0.4 nsec/gate. The devices are fabricated with a 1- μ m process that forms transistor elements on the entire surface of the chip. The series comprises five devices having densities ranging from 38,000 to 129,000 gates. The chips are reportedly compatible with the company's earlier ASIC devices, but will cost 20% more.—Joanne Clay

The New 4180 Plug-In

SPEED TRIALS.



- **Multi-channel:** two or four channel configurations.
- **Unmatched single-shot capabilities.**
- **High speed,** 200 MHz digitizing.
- **100 MHz analog input bandwidth.**
- **Real-time math functions.**

• **For your Free Speed Trial call:** 800-356-3090 or 608-273-5008

Nicolet Digital Oscilloscopes

Speed. Using the latest designs in ADC technology, your input signal can be digitized at speeds up to 200 MHz (5ns per data point) and saved for analysis. The wide band input amplifiers allow signals up to the 100 MHz Nyquist limit to be input without distortion. Sophisticated trigger setup displays allow you to accurately set the level, sensitivity, and slope to make one-shot transients easy to catch; eliminating the usual hit or miss guesswork. For multi-channel applications two 4180's can operate together in one mainframe producing a four channel scope with no degradation in speed or performance.

Real-Time Math. In addition to the extensive post-processing capabilities in the mainframe, the 4180 has several useful routines which present computed results as live, real-time displays: *FFT*, *MAX/MIN*, *A+B*, *A-B*, *A×B*, *A/B*, and *AVERAGING*.



Nicolet Test Instruments Division
P.O. Box 4288
5225-2 Verona Road
Madison, WI 53711-0288

Nicolet

INSTRUMENTS OF DISCOVERY

CIRCLE NO 165

SURFACE MOUNT MIXERS



\$2.49
(1,000 qty)

The opportunity for automated, low-cost assembly is a key benefit of surface-mount technology, but is often wiped out by the high price of surface-mount components. Now, Mini-Circuits offers a new series of mixers to meet the pricing demands of SMT ... only \$2.49 in 1,000 quantity (\$3.75 ea. in quantity of 10) ... at a cost even lower than most conventionally-packaged mixers.

The SCM-1 spans 1 to 500MHz with only 6.0dB conversion loss, 45dB LO-RF isolation, and 40dB LO-IF isolation. Housed in a rugged, non-hermetic 0.4 by 0.8 by 0.3 in. high (maximum dimensions) plastic/ceramic package. Spacing between connections is 0.2 in. The mixer is offered with leads (SCM-1L) or without leads (SCM-1NL) to meet a wide range of pc board mounting configurations.

Each SCM-1 is built to meet severe environmental stresses including mechanical shock/vibration as well as temperature shock. The operating and temperature storage range is -55°C to +100°C. Each SCM-1, designed and built to meet today's demanding reliability requirements, carries Mini-Circuits' exclusive 0.1% AQL guarantee of no rejects on every order shipped (up to 1,000 pieces).

When you think SMT for low-cost production, think of Mini-Circuits' low-cost SCM mixers.

SPECIFICATIONS (typical)	SCM-1L (with leads)	SCM-1NL (no leads)
FREQ. RANGE (MHz)		
LO, RF	1-500	
IF	DC-500	
CONVERSION LOSS (dB)		
Mid-Band (10-250MHz)	6.3	
Total Range (1-500)	7.5	
ISOLATION (dB)	(L-R)	(L-I)
Low-Band (1-10MHz)	60	45
Mid-Band (10-250MHz)	45	40
High-Band (250-500MHz)	40	35
PRICE	\$2.49 (1,000 qty)	
	\$3.75 (10-49)	

Units are shipped in anti-static plastic "tubes" or "sticks" for automatic insertion.

finding new ways ...
setting higher standards

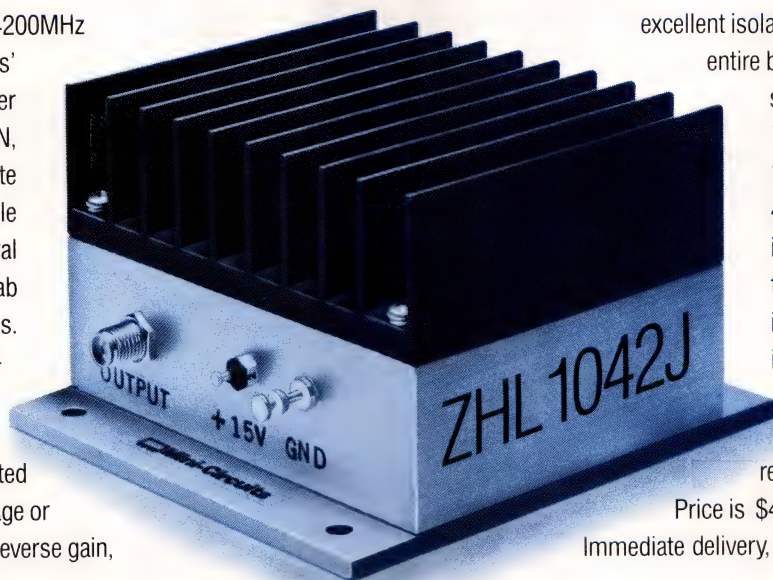
Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

how wide is a wideband amplifier ?

10 MHz to 4.2 GHz

With its ultra-wide 10 to 4200MHz bandwidth, Mini-Circuits' ZHL-1042J 100mW amplifier is ideally suited for EW, TACAN, mobile radio, and satellite communications. A single ZHL-1042J can replace several "wideband" amplifiers in lab and production test setups. *The three-stage, 27dB gain 50-ohm class A design provides unconditional stability; any load impedance can be connected without concern for damage or oscillation. With 50dB reverse gain,*



excellent isolation is offered over the entire band, critical for closely-spaced frequency tests. *The noise figure of 18dB at 10MHz rapidly drops to 4.5dB at 100MHz and above; input SWR is 2.5. Output at the +1dB compression point is +20dBm and the intercept point is +30dBm. The rugged heat-sinked 1.25 by 2.18 by 1.5 in. unit requires 15V, 0.3A. Price is \$495 (1-9 qty). Immediate delivery, 1-year guarantee.*

finding new ways...
setting higher standards

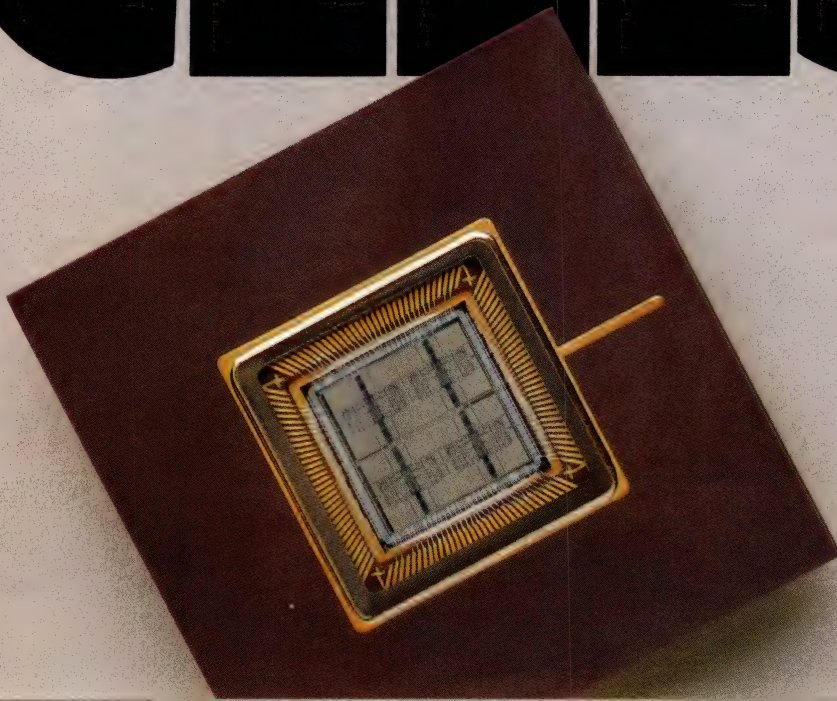
Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 166, Brooklyn, New York 11235 (718) 934-4500
Domestic and International Telexes: 6852844 or 620156

C106 REV. ORIG.

CIRCLE NO 167

BUILD KILLER CELLS.



This is the stuff reputations are built on.

A cell design with 100,000 gates. More than 1000 library elements. 2MB of memory. And sub-micron HCMOS technology.

You can search high and low, but there's only one place in the world you can find a chip of such staggering complexity.

LSI Logic.

Designs like this are precisely why we're the #1 domestic ASIC supplier with more than 4,000 working cell and array-based designs in the field.

And why our Modular Design Environment (MDE)[™] software is the best foundation for building killer cells.

MDE is the industry's most advanced design software for ASICs. It arms you with the capability to build today's most sophisticated cell-based designs. Easily. And with the smallest possible die size.

Besides MDE, LSI Logic delivers more than 400 LSI and VLSI building

blocks, including 16 and 32-bit micro-processor cells and industry-standard processor and peripheral functions; the longest list of SSI and MSI functions; and memory compilers to

develop exactly the RAM or ROM your chip requires.

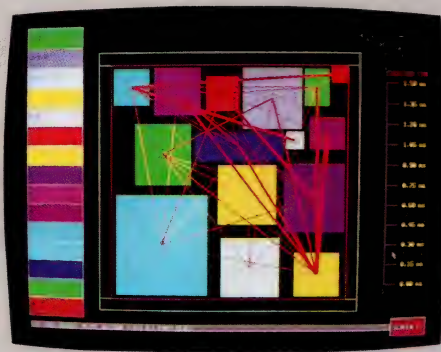
And if your application calls for lower densities, that's covered, too. Because LSI Logic has more cost-effective cell-based solutions than you can imagine.

No matter what kind of Cell-Based ASIC you build, LSI Logic will deliver a fully-tested prototype in as little as 4 weeks.

All in the production quantities you want, thanks to our advanced worldwide wafer fabrication, assembly, and test facilities.

So find out more about LSI Logic's Cell-Based ASICs by calling the sales office nearest you.

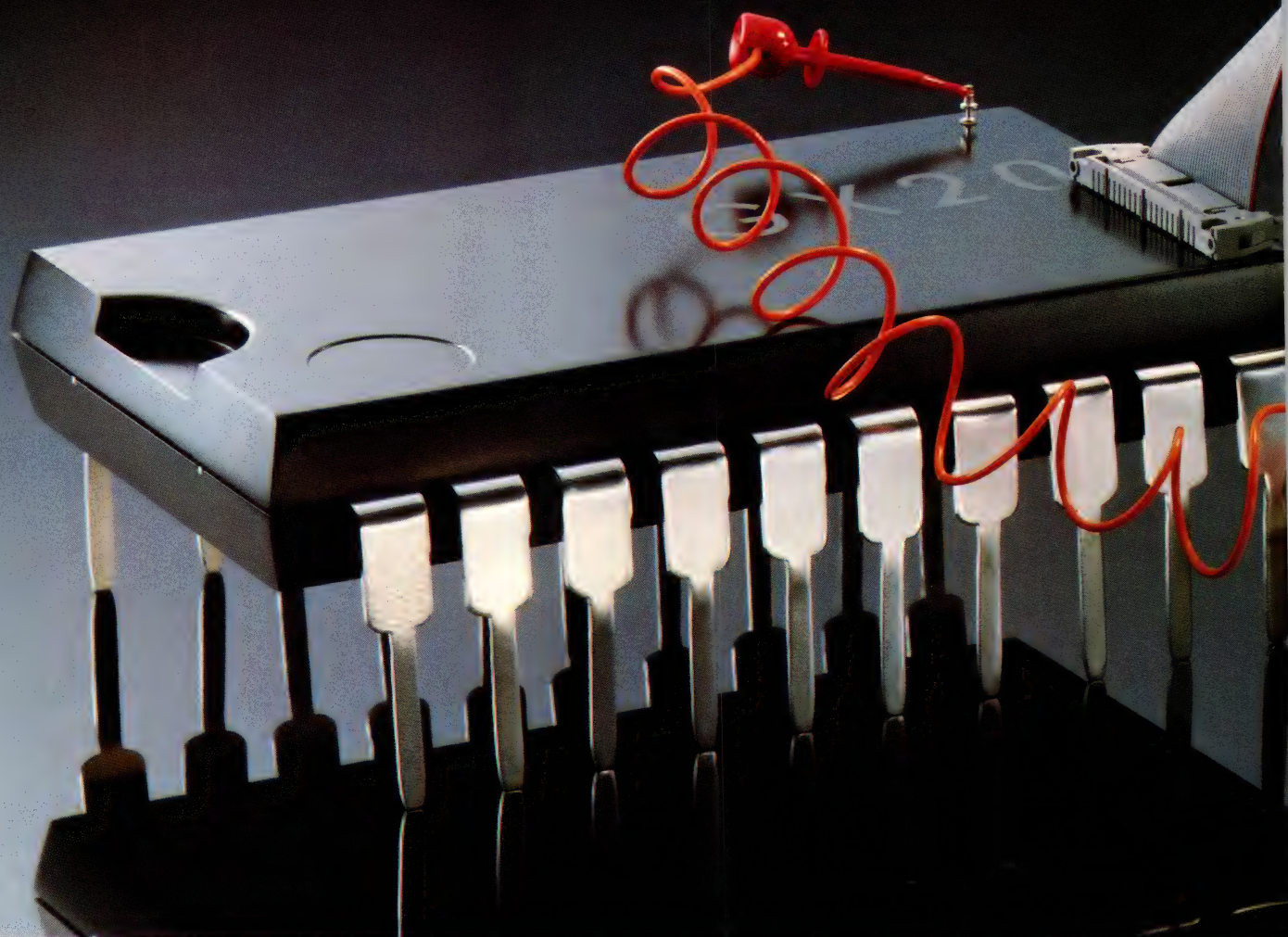
After all, we can help you make a killing.



High complexity Cell-Based ASICs require advanced tools like the MDE chip floorplanner to optimize delays and verify performance prior to layout.

LSI LOGIC

LSI Logic Sales Offices and Design Resource Centers: Scottsdale, AZ 602-951-4560, Milpitas, CA 408-433-8000, San Jose, CA 408-248-5100, Irvine, CA 714-553-5600, Sherman Oaks, CA 818-906-0333, Denver, CO 303-756-8800, Altamonte Springs, FL 305-339-2242, Boca Raton, FL 305-395-6200, Norcross, GA 404-448-4898, Chicago, IL 312-773-0111, Bethesda, MD 301-897-5800, Waltham, MA 617-890-0161, Ann Arbor, MI 313-769-0175, Minneapolis, MN 612-921-8300, Bridgewater, NJ 201-722-7522, Poughkeepsie, NY 914-454-6593, Raleigh, NC 919-783-8833, Worthington, OH 614-438-2644, Beaverton, OR 503-644-6697, Treviso, PA 215-638-3010, Austin, TX 512-338-2140, Dallas, TX 214-788-2966, Bellevue, WA 206-822-4384, Calgary, Alta 403-262-9292, Paris, France 33-1-46212525, Israel 972-3-403741/6, Milan, Italy 39-39-651575, Tokyo, Japan 81-3-589-2711, Seoul, Korea 82-2-785-1693, Nidau/Biel, Switzerland 032-515441, Bracknell, United Kingdom 44-344-426544, Munich, West Germany 49-89-926903-0. © 1988 LSI Logic Corporation. Modular Design Environment and MDE are trademarks of LSI Logic Corporation.



You wouldn't do this with your Analog VLSI devices.

You'll have to if you go to most ATE companies for a solution to today's sophisticated "system silicon" testing problems. Because all you'll get is a make-shift tester. And that means resigning yourself to man-months of custom hardware work integrating analog and digital instrumentation. And putting up with the long hours of low-level software development that go with custom solutions. Worse, you can expect these delays to cut your chances of getting your product to market on time.

Teradyne now has a simple answer to this complex testing problem. The A500 Analog VLSI Test System. It's the first of a new generation of systems specifically for AVLSI "system silicon" devices. A test system that can help you cut critical product development time by months or even years.

One Test System, Once and for All

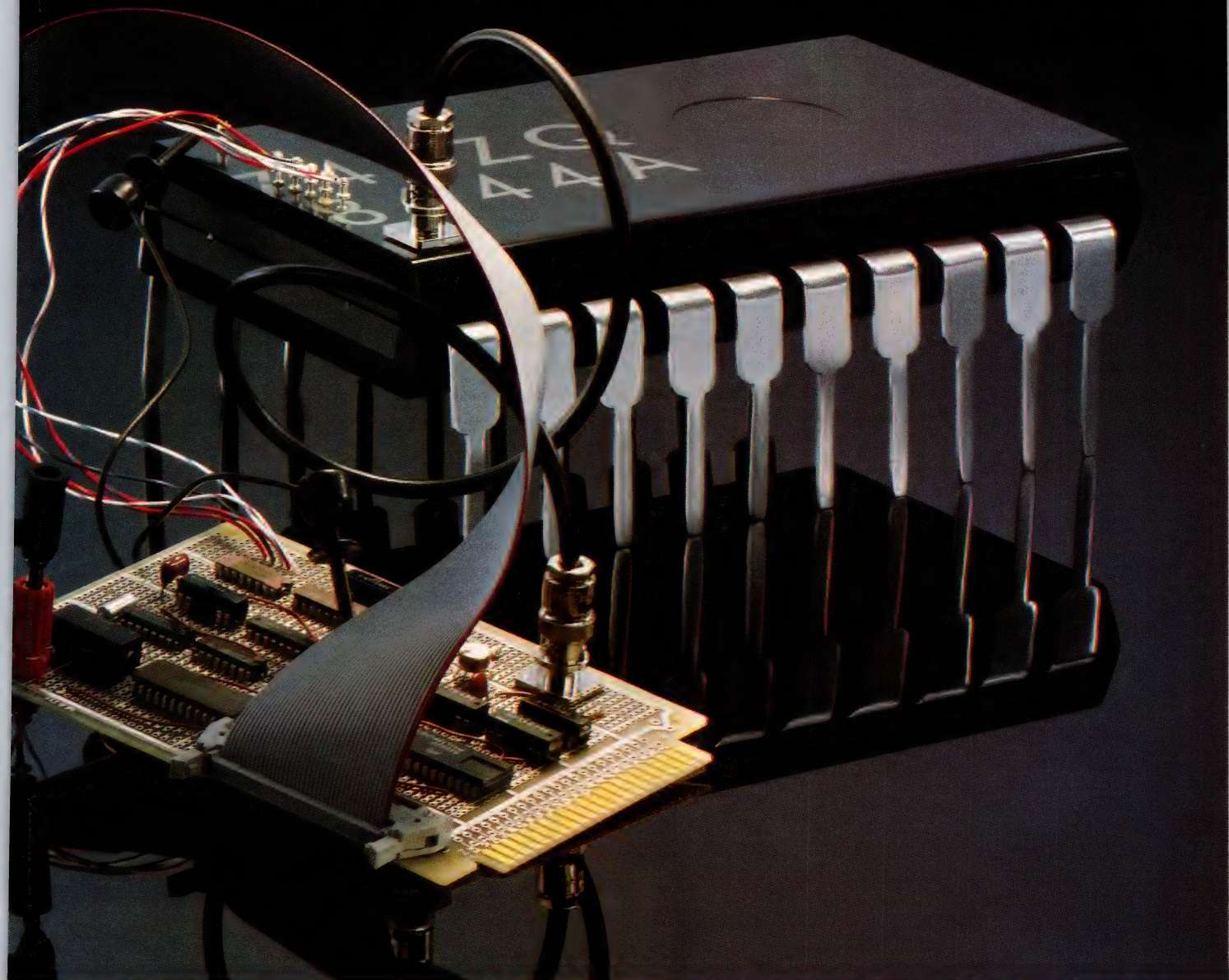
With AVLSI devices you won't get fast design feedback, unless you test individual components—the

"building blocks" of system silicon. And you won't comply with customer and industry requirements if you don't do complete "system" functional testing. With conventional test systems it means two of everything. Two testers, two test programs, two insertions, two data bases. And more than twice the time to get to market.

The A500 allows you to do it all with one system. So there's only one system to program. One insertion to make for both component and functional testing. And only one data base to work with. Which means significantly less time to market.

Vector Bus II™: the Great Integrator

The heart of the A500 is Teradyne's unique Vector Bus II architecture. It integrates analog and digital VLSI test capability at the system level. Which means you won't have to build special applications hardware for every new device you design. Vector Bus II eliminates that costly custom-work bottleneck



Why accept it in an Analog VLSI Test System?

with such features as TimeMaster™ Synchronization, Mixed-Signal Event Control, and MultiSource Data Mixing.

A Picture's Worth a Thousand Keystrokes

The A500 also revolutionizes program development. Our IMAGE™ (Interactive Menu-Assisted Graphics Environment) software gives you graphics programming as powerful as device designers' CAD/CAE tools. Using a mouse to control multiple windows, pop-up menus and software "power tools," you move ideas rapidly from mind to screen. And much faster to market.

Teradyne's new A500 is the only test system with the features you need to win the race for Analog VLSI market opportunities. To find out more, call Beth Sulak at (617) 482-2700, ext. 2746. Or call your nearest Teradyne sales office or write: Teradyne, Inc., 321 Harrison Avenue, Boston, MA 02118.



TERADYNE

We measure quality.

SIGNALS & NOISE

CAD systems can't replace breadboards

Thanks for printing Jim Williams's timely guest editorial ("Should Ohm's law be repealed?" EDN, March 3, 1988, pg 47). CAD systems certainly save time, especially when they're used for digital design. But claiming that a CAD system can eliminate the need for breadboarding analog circuits is like claiming that a text-processing package can produce a finished manuscript without any editing.

I would very much like to see EDN further explore the current status of analog circuit design. The gradual demise of analog courses in engineering schools is an important area of concern. Another is the replacement of simple analog circuits with complex programmable logic. Still another is the shunning, by digital-computer designers, of the analog computer, which is a well-

established, real-time, parallel processor.

*Forrest M Mims III
Seguin, TX*

A lesson in bridge building

I read with interest Jon Titus's editorial "Building bridges" (EDN, February 18, 1988, pg 53). It caught my eye because my son and I had a somewhat similar experience. Our experience was slightly different from Jon's, however, and as a result I believe I had a different outcome and a different lesson.

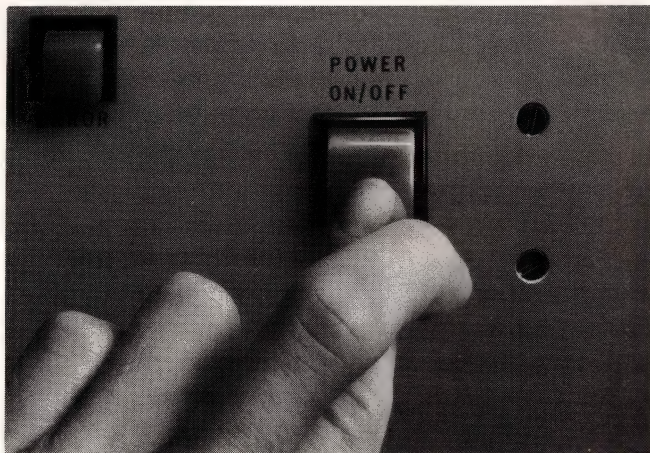
My son is in eighth grade. His science teacher provided a chance for the students to earn extra credit by designing a toothpick bridge that had to span approximately 11 in. and had to support a 10-lb lead ball. Every student who tried would get some credit, those who built bridges

that supported the weight would get more credit, and the student who built the lightest bridge that supported the weight would receive the most points.

I felt that this assignment was a good chance to provide some home education on how to approach problems that you are not especially trained to handle. (I am an electrical engineer, and my Statics class was many years ago.) We first determined how strong a toothpick was. Then we built a few small trial structures to determine how much they would support. This experiment led us to a design that not only supported the weight but was also the lightest. We did it without calculations or detailed engineering. We used a logical step-by-step approach and trial and error. Although it wasn't the fastest approach, it got the job done.

My point is that too often we get

THEIR APPROACH. OUR APPROACH.



It can be the scariest part of design.

When you turn your design — your "baby" — over to the folks who will turn it into hardware.

Cross your fingers no longer. Standard Logic will do the job right and do it on time. The whole job. Or any part of it you want.

45 different embedded-capacitor, DIN-standard Metric Series logic cards in three different pin patterns and 15 sizes are available.

All are tin-lead-alloy-plated for whisker-free reliability.



They're perfect for your own proprietary bus, VME-bus, Multibus II, Futurebus or NuBus interfaces. We even provide matching extender cards, rugged chassis, enclosures and back panels.

Now you'll know when you push the button it'll work. Simply call or write: Standard Logic Inc., 4940 East La Palma Ave., Anaheim, CA 92807.

714/779-2897.

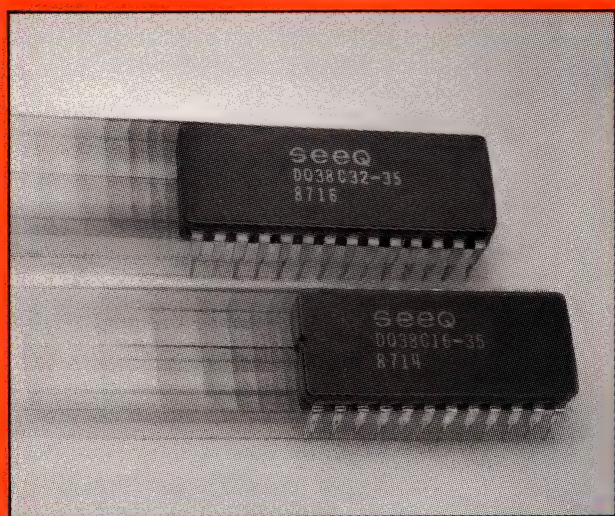


STANDARD LOGIC INC.

Bringing your designs to life.

THERE'S MORE IN STORE FROM SEEQ.

High-Speed E²PROMs. There's No Waiting in Our 45-nsec Line.



Org.	Part No.	Pin Out	I _{cc}	T _{aa}	T _{ce}	Packages
2K x 8	36C16	Same as bipolar PROM	100 mA	45 ns	30 ns	DIP, LCC
4K x 8	36C32	Same as bipolar PROM	100 mA	45 ns	30 ns	DIP, LCC
2K x 8	38C16	JEDEC STD E ²	100 mA	45 ns	30 ns	DIP, LCC, PLCC
4K x 8	38C32	JEDEC STD E ²	100 mA	45 ns	30 ns	DIP, LCC, PLCC

All parts are available in MIL-STD 883, Class B.

There was a time when you couldn't consider E²PROMs for writeable control-store applications. Because their speeds couldn't keep up with today's faster microprocessors, without introducing wait states.

But with SEEQ's 16K and 32K CMOS parts, that's all changed. Their 45-nsec speeds—along with in-system reprogrammability—are opening up new applications in areas like array processing, graphics and DSP. High-performance areas where slower E²s just can't make it.

That means your options in fast, non-volatile memory just got a lot broader than bipolar PROMs. And much more flexible. Because at 350 mW, our CMOS parts consume less than half the power of bipolar PROMs. While still delivering comparable output drive characteristics.

Available in JEDEC-approved byte-wide pinouts, these E²s operate over extended and full military temperature ranges.

SEEQ high-speed E²PROMs can also replace—and outperform—your other traditional alternative, slower E²s combined with fast SRAMs. That simplifies designs by eliminating the need to load RAM for program execution. And, fast E²s cut the number of required devices by more than half.

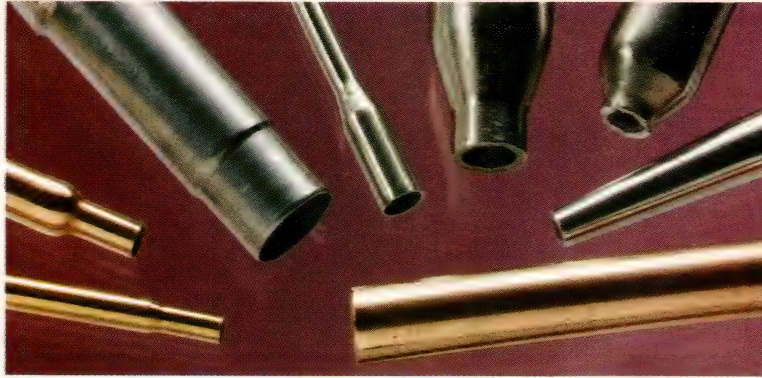
At SEEQ, we have a lot more in store. SEEQ Technology, Inc., 1849 Fortune Drive, San Jose, CA 95131.

**Call Us On It:
(408) 432-9550**

seeq

E² Is Our Middle Name

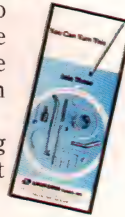
the unlimited design benefits of miniature metal tubing.



design benefits number 505 and 506 **REDUCING/EXPANDING**

Small tubing diameters can be reduced or expanded up to 50% of the original diameter with exacting tolerances. The standard transition angle of 13° allows a means to regulate fluid or air flow, locate an internal or external position, or join one diameter to another.

You'll find a lot of design options in our small tubing booklet. Or talk directly to our design specialists at 1-800/321-6285.



UNIFORM TUBES, INC.

Collegeville, PA 19426-0992 • Telephone: 215/539-0700
TWX: 510-660-6107 • Telex: 84-6428 • FAX: 215/489-1150
In Europe: UTI U.K. 983-404049 • Telex: 869441 UTIUK G

CIRCLE NO 4

INTRODUCING THE HI-REL MAJOR PATRIOT AC FAN

Comair Rotron's Hi-Rel Major and Patriot tubeaxial AC fans are 10% more efficient, offer 10°C cooler bearing temperatures and provide as much as five years longer life for continuous operation.

- Operating temperatures range from -10°C to +70°C at 240 CFM
- Fan diameter is 6.75" x 2" deep
- At 40°C Hi-Rel fans have an L10 Life of 102,000 hrs.

Comair Rotron's Hi-Rel fans continue the tradition of responding to the industry's increasing demand for higher reliability, precisely engineered airmovers.

Comair Rotron. The First Name in Forced Convection Cooling Technology.



HI-REL COMAIR ROTRON

For literature only call 800-367-2662. In NYS and for product or technical assistance call our application Engineering Dept. at (914) 246-3615.

a KLI company

12 North Street Sawyer Industrial Park, Saugerties, N.Y. 12477-1096
Telephone: (914) 246-3615 TWX 910-333-7572 Telex: 551496

CIRCLE NO 5

SIGNALS & NOISE

wrapped up in the requirement that we must always have the slickest, best, fastest, and most state-of-the-art tools to get the job done. Sometimes I wonder how anything was ever designed before we had HP calculators, personal computers, and engineering workstations. Many designs have been done without the aid of any of these tools, and hopefully many more will be in the future.

I am not a Luddite when it comes to using tools to do a better job. However, I think that our colleges are turning out students that need the latest equipment to get the job done. This situation has been caused in part by employers who expect engineers fresh out of school to be versed in the latest equipment and ready for design work. The end result is that the education the students receive is leaning more toward practical skills and less toward theoretical skills and a broad education. I believe that in the long run this situation will be detrimental to the engineer's ability to keep up with technology or adapt to a different technology should the job require it.

Let's not forget that you can accomplish a lot by using the best computer available (the one between your ears), a little common sense, and a logical approach to a problem. Sometimes the simplest solution is the best solution.

Joe Blaschka, Jr, P E

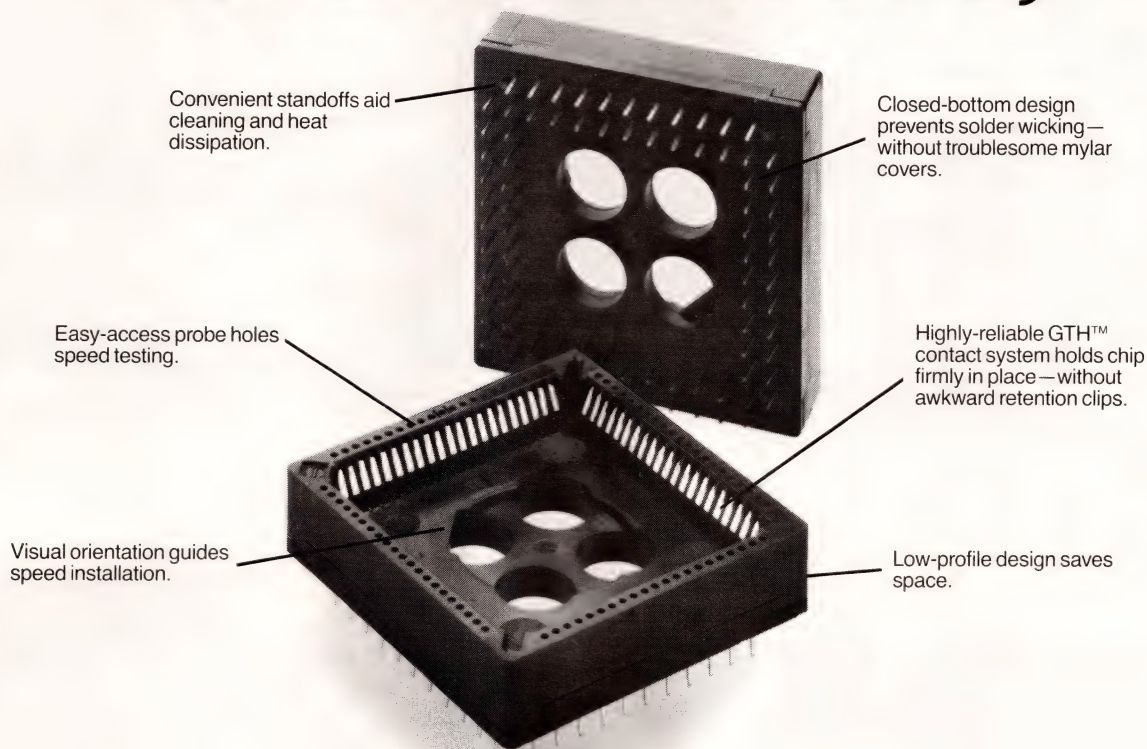
President

*Adcomm Engineering Co
Kirkland, WA*

Sorry, wrong number

The phone number listed for Softaid Inc (Columbia, MD) on pg 253 of EDN's March 17, 1988, issue is incorrect. The correct number is (301) 964-8455.

WITH ALL THIS GOING FOR YOU,



Convenient standoffs aid cleaning and heat dissipation.

Closed-bottom design prevents solder wicking — without troublesome mylar covers.

Easy-access probe holes speed testing.

Highly-reliable GTH™ contact system holds chip firmly in place — without awkward retention clips.

Visual orientation guides speed installation.

Low-profile design saves space.

WHY SETTLE FOR ANYTHING LESS IN A CHIP CARRIER SOCKET?

CHIPAK™ — it's the finest chip carrier socket on the market today. And the only one that combines all these important features in a single design.

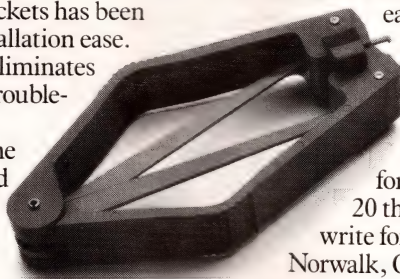
In fact, everything about our CHIPAK sockets has been engineered for maximum reliability and installation ease.

Our closed-bottom design, for example, eliminates the danger of solder wicking — without the troublesome mylar covers required in open-bottom designs. Our GTH™ contact system grips the chip tightly in place and insures good-as-gold performance — without cumbersome chip retention clips.

In short, CHIPAK combines all the

features you'll ever want or need in a chip carrier socket.

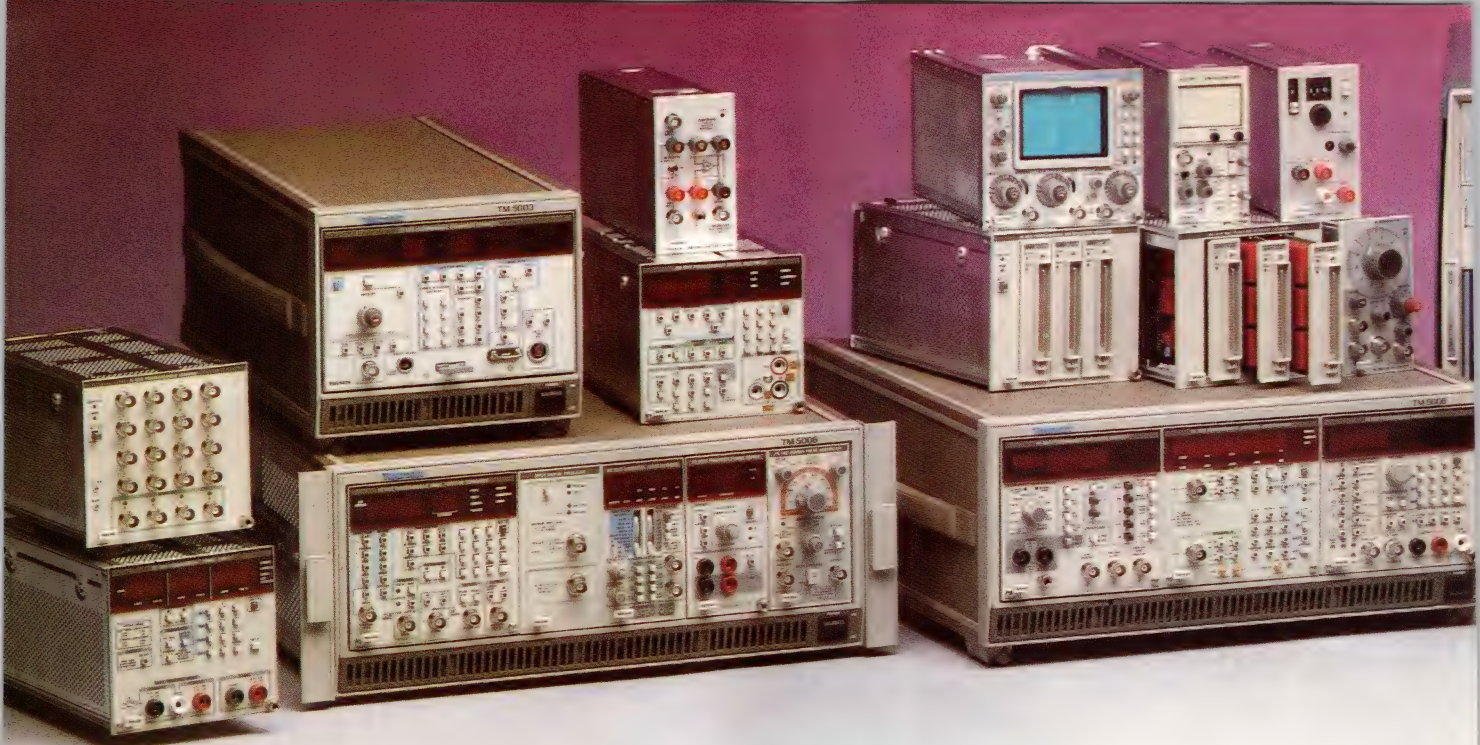
Low-profile design to save space. Convenient standoffs to aid cleaning and heat dissipation. Easy-access probe holes and easy-to-spot orientation guides to speed installation and testing. And finally, an easy-to-use chip extraction tool that, unlike others, accommodates every socket size — quickly and safely.



With all this going for you, why settle for anything less? Available in sizes from 20 through 84 contact positions. Call or write for complete details: Burndy Corporation, Norwalk, CT 06856. (203) 852-8337.

THE BEST CHIP EXTRACTION TOOL IN THE BUSINESS!
Foolproof. Easy to use. Convenient. One tool does it all. Accommodates full range of chip sizes.

 **BURNDY**
CUSTOMER SATISFACTION COMES **FIRST**



NEW FROM TEK: ANALOG FUNCTION, ARBITRARY WAVEFORM AND SWEEP GENERATION IN ONE COMPACT PACKAGE.

The Tek AFG 5101 Programmable Arbitrary/Function Generator is the latest addition to Tek's TM 5000 family of proven, programmable, modular test instruments.

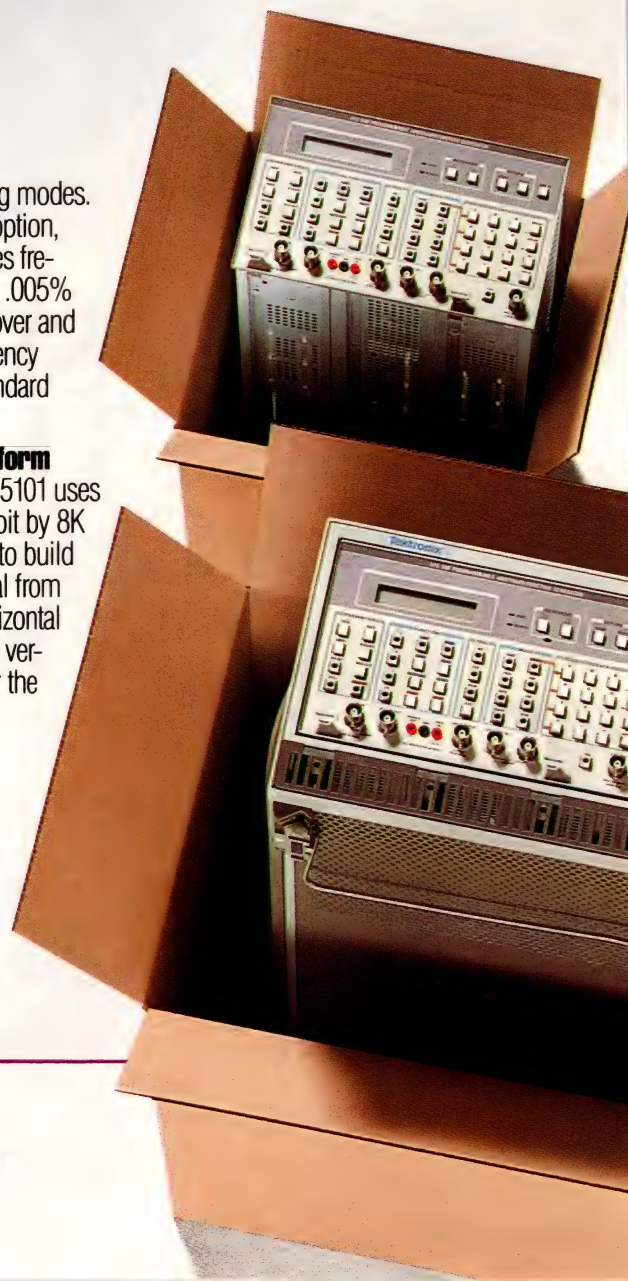
An analog function generator, the AFG 5101 can generate standard sine, square and triangle waveforms, plus dc level, with frequencies from .012 Hz to 12 MHz and amplitudes of 10 mV to 9.99V peak-to-peak, into 50 ohms. Waveforms can be continuous, triggered, gated or burst, from a

full range of triggering modes.

With synthesizer option, the AFG 5101 achieves frequency accuracies to .005% (120 Hz to 12 MHz) over and above the .2% frequency accuracies in the standard instrument.

An arbitrary waveform generator, the AFG 5101 uses two independent 12-bit by 8K waveform memories to build any imaginable signal from an array of 8,192 horizontal addresses and 4,096 vertical addresses. Enter the waveforms manually from the front panel, from computer data—or select one of the unit's predefined, 1,000-point waveforms.

A sweep generator, the AFG 5101 includes linear,





logarithmic and arbitrary sweeps, with any sweep usable in continuous, triggered, gated or burst mode. Users can receive instant frequency readout of breakpoints, notches, or response anomalies.

The applications are wide open. Use the AFG 5101 to drive sensors, timers, and other R&D equipment. To simulate metal stress or vibration characteristics. To teach waveform theory to students. And much more.

Easy waveform editing capabilities... non-volatile storage of up to 99 front panel settings and two 8K point waveforms... binary block GPIB transfer... two waveform memories plus third, execution memory—these and other features make the AFG 5101 a simple, powerful and uniquely flexible tool.

AVAILABLE IN THREE CONFIGURATIONS.

The first triple-duty test instrument of its kind, it is available in monolithic (AFG 5501), as a plug-in (AFG 5101), or in our Programmable Arbitrary Stimulus/Measurement package (EBS 5002).

Take 10% off with our package offer. Order the AFG 5101 in our Programmable Arbitrary Stimulus/Measurement package and take 10% off catalog prices.

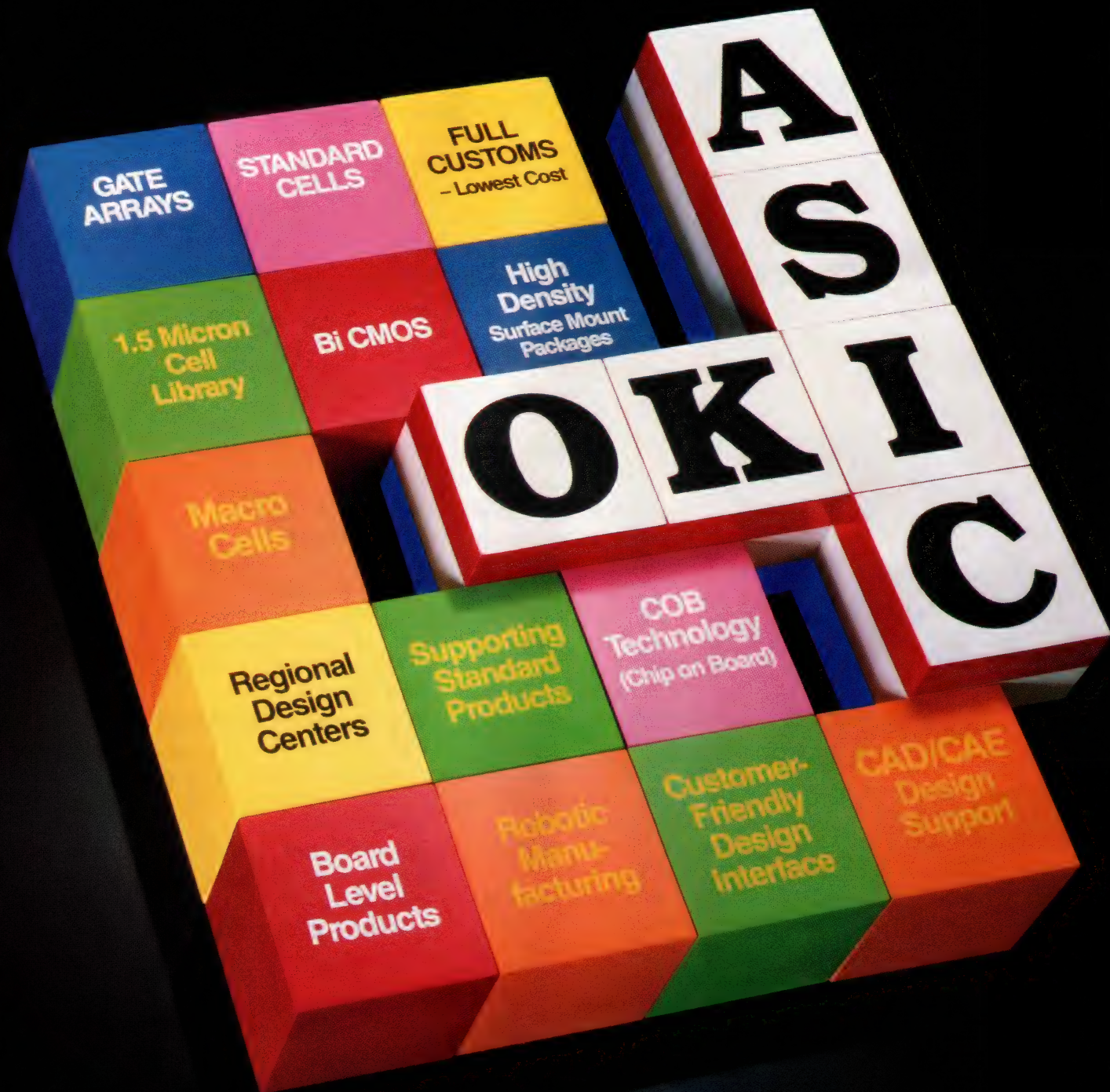
For the full story on these and other Tek modular instruments, call 1-800-426-2200. Or contact your nearby Tektronix field office.

(Center photo) The AFG 5101 can be ordered in either monolithic version, top right, or as a plug-in for the TM 5000 series mainframes, top left. Or, combine it with the DM 5010 4.5 Digit Multimeter and DC 5009 135 MHz Digital Counter within a TM 5006 mainframe (EBS 5002), as shown at bottom, and take 10% off the normal catalog price.

Tektronix
COMMITTED TO EXCELLENCE

CIRCLE NO 172

Easy ASIC



Only from OKI:

- Most **complete** ASIC building blocks.
- Most **versatile** design/package options.
- Most **experienced** ASIC technology.

Nobody but nobody puts ASIC technology together like OKI Semiconductor can.

Ease into ASIC with OKI as your close working partner—and you instantly support your VLSI application with the most comprehensive ASIC capabilities on the world market today. Bar none.

From gate array, standard cell and full custom chips to standard components to integration to advanced board level products, OKI alone puts you on the leading edge of ASIC technology and its complete implementation.

OKI: the totally logical choice.

Opt for OKI ASIC, and you open up your options across the board. Only OKI now offers the system designer the unique security and entry ease that only a proven track record in CMOS ASIC problem-solving can provide. This history of performance built up since 1977 has produced the widest range of solid building blocks yet: advanced ASIC products and packaging including surface-mount, backed up with the most flexible cell libraries, CAD/CAE design tools and development aids.

As your working partner, OKI ASIC expertise is available to you at any stage of the development process. We'll help you define system requirements, determine the most cost-effective product solutions and supply complete design software—accessible at your own workstation or through our regional design centers. And then we take it from there: with high

volume fabrication, assembly and testing completed in one of the world's most highly robotized manufacturing facilities.

Compare Total ASIC Capabilities	OKI ASIC	Source "B"	Source "C"
Gate Arrays to 10K Gates	●	●	
Standard Cells to 30K Gates	●	●	
Full Customs – Lowest Cost	●		
1.5 Micron Cell Library	●	●	●
Macro Cells	●	●	
Bi CMOS	●		
High Density Surface Mount Packages	●		
Board Level Products	●		
Supporting Standard Products	●		
COB Technology (Chip on Board)	●		
CAD/CAE Design Support	●	●	●
Customer-Friendly Design Interface	●	●	●
Regional Design Centers	●	●	●
Robotic Manufacturing	●		

ASIC Solutions from **OKI:**
You can't beat the logic!

Check out OKI ASIC data:

EDN051288

Please rush complete technical data/specs on OKI capabilities in:

- () Gate Arrays
() Standard Cells
() Full Customs
() Please call: we have immediate requirements:

Name/Title _____

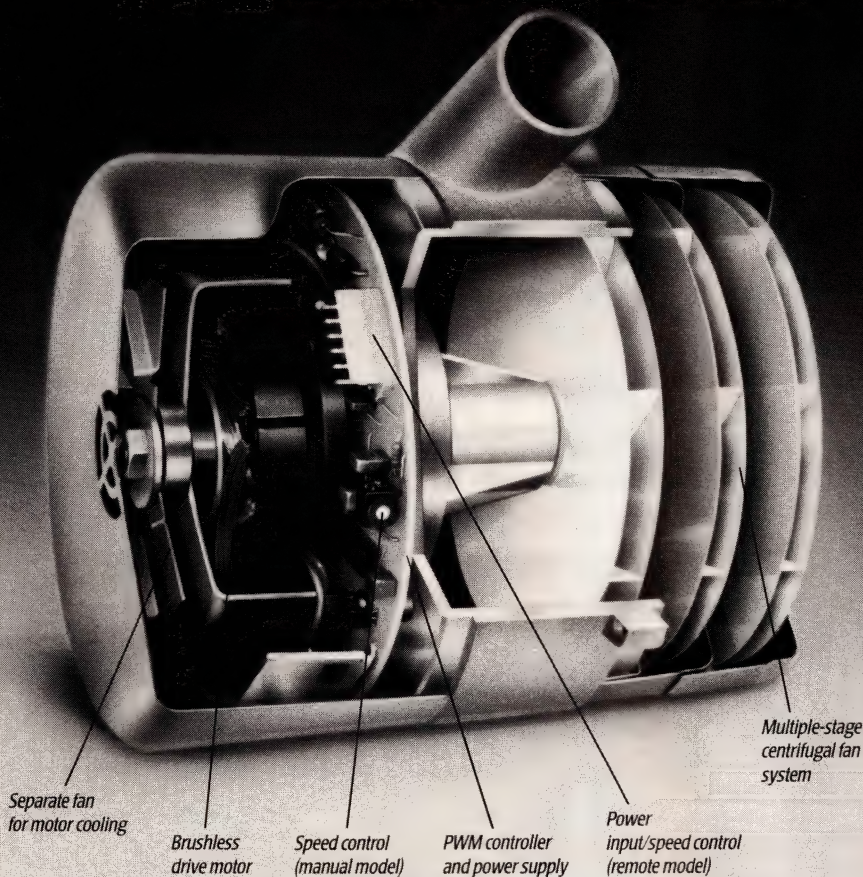
Company _____

Attach coupon to business card or letterhead and return to: ASIC Customer Service, **OKI Semiconductor**, 650 North Mary Avenue, Sunnyvale, CA 94086. Tel: (408) 720-1900.

CIRCLE NO 173



Now, high performance vacuum/pressure blowers that operate from 120 VAC



Separate fan for motor cooling

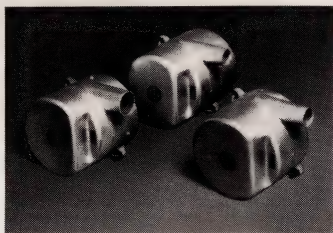
Brushless drive motor

Speed control (manual model)

PWM controller and power supply

Power input/speed control (remote model)

Multiple-stage centrifugal fan system



Compact units feature brushless dc motors with integral controller and variable speed capability

These new Wind-jammer® blowers combine electronics, motor, and fan system in a compact, cost-effective package that operates from a standard 120 VAC input. An exclusive

Lamb Electric design, they were developed for demanding, limited space applications such as business machines, medical equipment and materials handling applications.

Just 5.7" in diameter, the blowers have 1-, 2-, or 3-stage fans for performance from 50" H₂O vacuum at 0 CFM to 110 CFM at 0" H₂O. With one version, a 0 to 10

VDC signal from a sensor or other device will control motor speed and adjust air performance from 0 to 100%. Or, a second model provides manual speed control by means of a potentiometer located in the blower housing.

These blowers also feature low noise performance and are UL/CSA component recognized. Get complete details by contacting AMETEK, Lamb Electric Division, 627 Lake Street, Kent, OH 44240. (216) 673-3451. Telex: 433-2140. Cable: LAMETEK.

AMETEK
LAMB ELECTRIC DIVISION
CIRCLE NO 6

CALENDAR

31st Annual Instrument Society of America Power Symposium, St Petersburg, FL. Bill Blazier, Illinois Power Co, 500 S 27th St, Decatur, IL 62525. (217) 424-6622. May 23 to 25.

Society for Information Display International Symposium, Anaheim, CA. Palisades Institute for Research Services, 201 Varick St, Rm 1140, New York, NY 10014. (212) 620-3388. May 23 to 27.

C Programming: Hands-on Workshop (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. May 24 to 27.

Troubleshooting Microprocessor-Based Equipment and Digital Devices (seminar), Kansas City, MO. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. May 24 to 27.

DOD-STD-2167A and DOD-STD-2168—Defense System Software Development (seminar), San Diego, CA. David Maibor Associates, Box 846, Needham, MA 02194. (617) 449-6554. May 26 to 27.

Troubleshooting Microprocessor-Based Equipment and Digital Devices (seminar), Dallas, TX. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. May 31 to June 3.

42nd Annual Frequency Control Symposium, Baltimore, MD. R L Filler, US Army Electronics Technology and Devices Lab, Attn: SLCET-EQ, Ft Monmouth, NJ 07703. (201) 544-2467. June 1 to 3.

Personal Computer Interfacing for Scientific Instrumentation Automation (short course), Blacksburg, VA. Linda Leffel, CEC, Virginia Tech, Blacksburg, VA 24061. (703) 961-4848. June 2 to 4.

Record-Shattering CPU Performance!

***Sustained 20-MIPS, 7-MFlop
throughput in a 32-bit CMOS
CPU and FPU.***

***Nothing else
comes close.***

What happens when you blend our ultra-fast PACE Technology™ with MIPS, the top-performing RISC architecture?

Simple—a breakthrough of major proportions. A 32-bit CPU/Floating point processor set that delivers *sustained* throughput of 20-MIPS, and 7-MFlop single precision, LINPACK, or 4-MFlop double precision. (Peak throughput exceeds 25-MIPS.)

There's more. The market-rattling performance of the PaceMips™ R3000 and R3010 is supported by 256K bytes each of high-speed instruction and data cache memory. The speed, as you might expect, is made possible by our 64K, 16K and 4K SRAMs—the world's fastest—in x1, x4 and x8 organizations.

If record-shattering performance interests you, you'll call our marketing HOT LINE today at (408) 734-9000 for more information. On pricing. Operating systems. Compilers. Development systems. And fast static RAMs.

The PaceMips R3000 and R3010. Ready now. With champion performance that can make your next system a winner, too.



Performance Semiconductor Corporation
610 E. Weddell Drive, Sunnyvale, CA 94089
Telephone (408) 734-9000

CIRCLE NO 174

PACE Technology is a trademark of Performance Semiconductor Corporation.
PaceMips is a joint trademark of Performance Semiconductor Corporation and
MIPS Computer Systems, Inc.



OTTO®
Sealed Switches

New!
Alternate Action

Dry Desert to Wet World

Survival! That's what you can expect from OTTO precision snap-action pushbutton switches. Sealed to survive the rigors of industrial, commercial and military applications, these switches are available in momentary and alternate (push-on, push-off)

action, miniature and subminiature sizes, choice of front panel appearance and button colors.

Sealed against dirt and water. Electrical ratings from computer level to 10 Amperes. Contact resistance < .025 ohms.

OTTO®
CONTROLS Division, OTTO ENGINEERING, INC.

2 East Main Street • Carpentersville, Illinois 60110 • Phone: 312/428-7171 • FAX 312/428-1956 • TELEX: 72-2426

CIRCLE NO 7



SUPER POWER!

High reliability ELCOM® brushless DC servo motors are ideally suited to continuous process applications as well as demanding motion control functions in automated equipment. Optional, integrally mounted optical encoders facilitate use with latest digital control systems. Now available in 3 frame sizes and multiple lengths up to 50mm square x 100.4mm long. Continuous duty outputs to 47 oz.-in. at 7,200 rpm (1/3 hp). For complete information on how ELCOM® brushless motors can improve your design, call PITTMAN at (215) 256-6601.

PITTMAN®
HARLEYSVILLE, PA 19438-0003 USA
A DIVISION OF PENN ENGINEERING & MANUFACTURING CORP.

CIRCLE NO 8

CALENDAR

International Summer Consumer Electronics Show, Chicago, IL. Consumer Electronics Shows, 2001 Eye St NW, Washington, DC 20006. (202) 457-8700. June 4 to 7.

FiberTour 88, Boston, MA. Joan Barry, Xpos, Box 8872, Salem, MA 01971. (617) 744-9767. Conference cosponsored by Lightwave magazine. June 7 to 8.

ATE & Instrumentation Conference East, Boston, MA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. June 7 to 9.

International Conference on Consumer Electronics, Rosemont, IL. Geriann Van Calbergh, 4924 N Cumberland, Norridge, IL 60656. June 7 to 10.

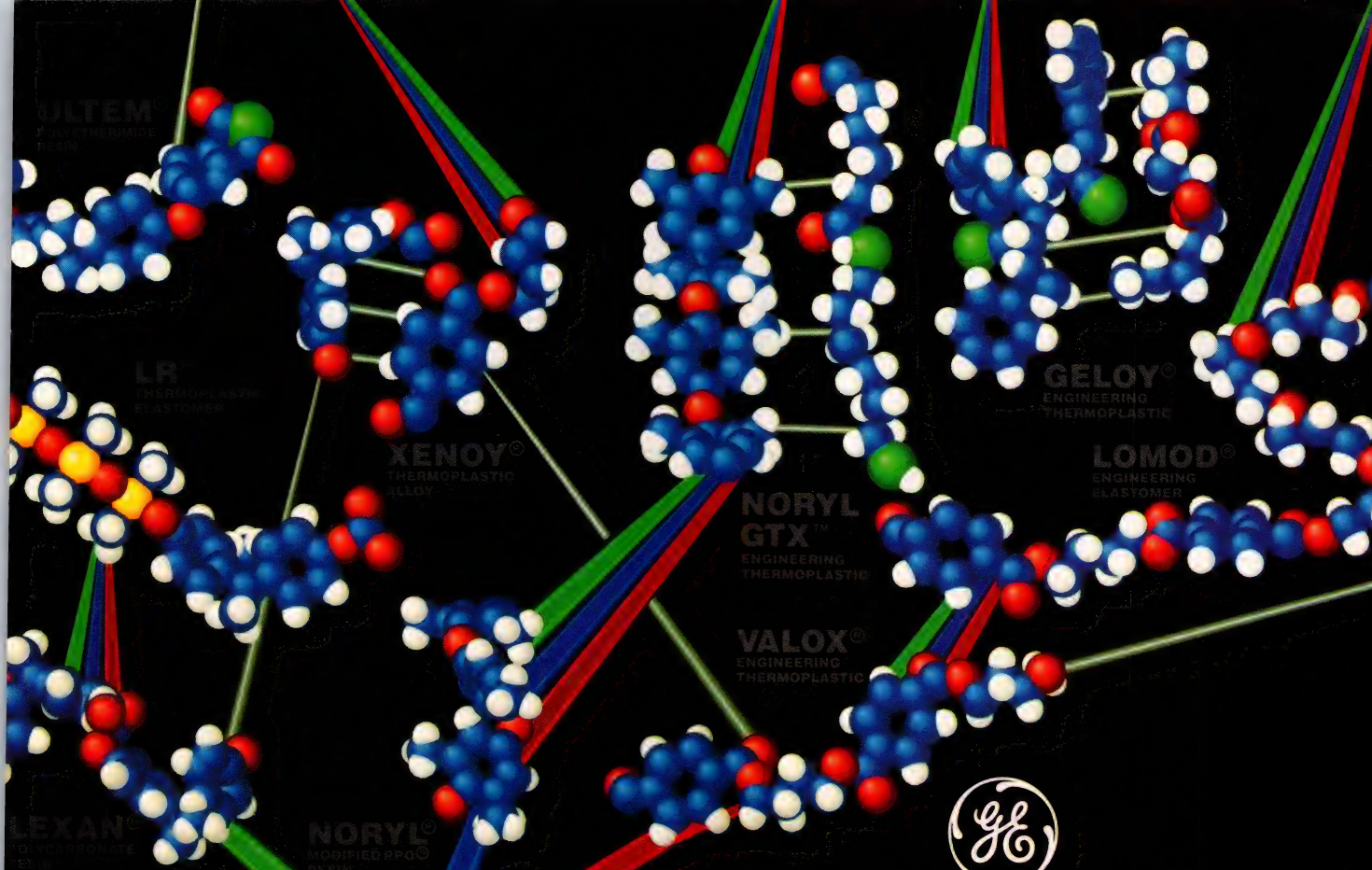
25th Design Automation Conference, Anaheim, CA. MP Associates, 7366 Old Mill Trail, Suite 101, Boulder, CO 80301. (303) 530-4333. June 12 to 15.

Nepcon East, Boston, MA. Cahners Exposition Group, 1350 E Touhy Ave, Des Plaines, IL 60018. (312) 299-9311. June 14 to 16.

Worst-Case Circuit Analysis (seminar), Honolulu, HI. Design and Evaluation, 1000 White Horse Rd, Suite 304, Voorhees, NJ 08043. (609) 770-0800. July 11 to 13.

CASE '88 (2nd International Workshop on Computer-Aided Software Engineering), Cambridge, MA. Pamela Meyer, Index Technology Corp, 1 Main St, Cambridge, MA 02142. (617) 494-8200, ext 1988. July 12 to 15.

Siggraph, Atlanta, GA. Barbara Voss, Robert P Kenworthy Inc, 866 United Nations Plaza, Suite 424, New York, NY 10017. (212) 752-0911. August 1 to 5.



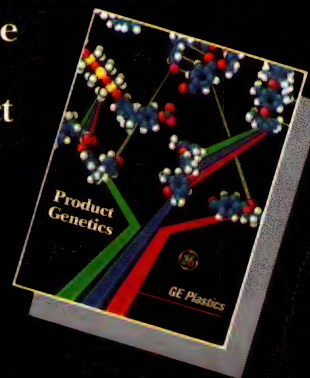
GE Plastics

Product Genetics.

Progressive generations of superior materials: copolymers, alloys, composites. Selectively bred to perform.

The GE family tree. Breadth and depth of product technology, creating opportunities for ultimate design and performance. The basic building blocks of innovation: materials excellence enhanced by a unique matrix of program development resources—only from GE.

For a performance profile of the leading family in engineering plastics, request our free Product Genetics Brochure today:
(800) 845-0600.



CIRCLE NO 175

* Registered Trademarks. ** Trademarks of General Electric Company.

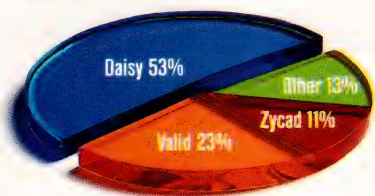
DO YOU HAVE WHAT IT TAKES TO MAKE IT BIG IN ASICS?

Not long ago, designing ASICs wasn't even part of your job. Now it's the part everyone's counting on.

That's where Daisy comes in.

Daisy CAE tools are used by more ASIC designers than any other CAE workstations.

Because from schematic creation through post-layout



Simulation accelerator market share. Source: Prime Data, 1985 and 1986 unit shipments.

simulation, Daisy has what it takes to keep ASICs on time and on budget.

For example, our MegaLOGICIAN™ simulation

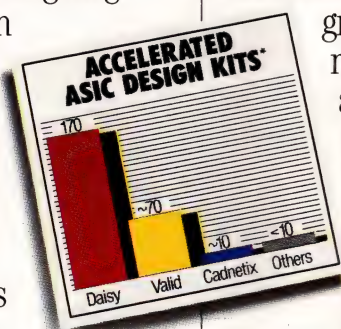
accelerator is seamlessly integrated with the schematic, so you can locate and correct design problems interactively. That means faster debugging and more time to improve the quality of your design. Plus

no other accelerator is as well supported,

with more than 170 design kits supplied by 70 different vendors. So you can build productivity instead of libraries.

Which may explain why more MegaLOGICIANS are in use today than all other accelerators combined.

Speaking of combining, you



can share a MegaLOGICIAN with a network of our 386-based desktop workstations, for a high-powered low cost ASIC design environment.

And that's just the beginning.

With our library of more than 4,500 system-level components, you can include your ASIC in complete "real world" system simulations to ensure that your designs will be ready for production, instead of revision.

All of which makes Daisy today's choice for no-sweat ASIC success.

But what about tomorrow?

Gate counts are on the rise. If your tools run out of steam at 5,000 gates, so could your future.

No problem.

Our ASIC design tools glide through 20,000-

**DEAD
END**

gate designs without even breathing hard.

In fact, new design kits already support arrays of over 100,000 gates.

So you'll never have to worry about hitting a dead-end.

But don't take our word for it, listen to what

Rockwell and other industry leaders have to say. For a free copy of "Making It Big In ASICs" call Daisy at 1 (800) 556-1234, Ext. 32. In California, 1 (800) 441-2345, Ext. 32.

European Headquarters:
Paris, France (1) 45 37 00 12.
Regional Offices:
England (256) 464061;
West Germany
(89) 92-69060;
Italy (39) 637251.



Expand your



design vision.

Enhance your design at any stage with RCA CMOS 6805 micros and SPI peripherals.

Your challenge is to increase system performance and capability while reducing board size.

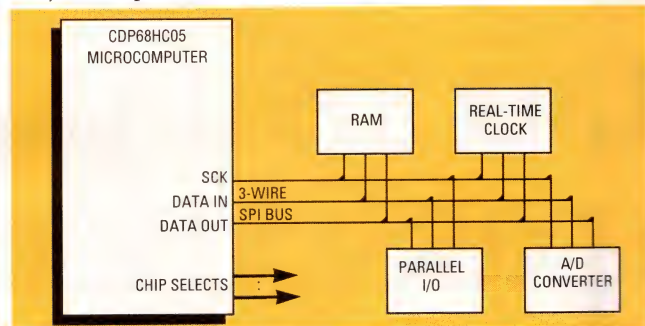
Not an easy job. But certainly easier when you use our 6805 and 68HC05 micros and serial peripheral interface devices.

Extend your micro's power.

Many microcomputers rely on parallel I/O ports to communicate with peripheral devices. An inefficient method at best.

That all changes with the serial peripheral interface incorporated into our 68HC05 microcomputers.

This three-wire (plus device select) synchronous, full-duplex, serial communication system contains separate lines for input and output data, serial clock and device select. You don't have to sacrifice I/O ports to communicate off-chip: our 68HC05 micros can communicate with our own serial peripherals, the serial peripherals of other manufacturers, and even with other microcomputers via only three port lines.



True design versatility.

The real beauty of the SPI is that it eliminates limitations imposed by microcomputers.

For example, you can easily extend the amount of I/O or memory with SPI RAMs, I/O chips or shift registers. And the modular SPI bus gives you the ability to expand without losing lots of PC-board space. Reduced package sizes and minimized interconnect wiring lead to reduced board size.

And since you don't need complex software to

operate the bus, you save ROM space.

Right now, we can offer you a versatile family of peripheral devices, including 128-byte and 256-byte static RAMs, a real-time clock with RAM, an 8-bit programmable I/O port, and a 10-bit 8-channel A/D converter. And more parts are coming soon, including a digital pulse-width modulator and a serial bus interface chip for networking microcomputers. These serial peripherals are also compatible with other microcomputer types.

Powerful family of micros.

We can provide 6805 microprocessors for external memory address, but the heart of our SPI system is the 6805 Series high-speed CMOS microcomputers:

68HC05 Microcomputers

Features	68HC05C4	68HC05C8	68HC05D2	68HC05D2A
Pins	40	40	40	28
On-Chip RAM (bytes)	176	176	96	96
On-Chip User ROM (bytes)	4160	7744	2176	2176
Bidirectional I/O Lines	24	24	28	16
Unidirectional I/O Lines	7 inputs	7 inputs	3 inputs	3 inputs
Timer size (bits)	16	16	16	16
Prescaler size (bits)	*	*	*	*
External timer oscillator	no	no	yes	yes
Serial peripheral interface	yes	yes	yes	no
Serial communications interface	yes	yes	no	no

*prescaler fixed as :4

Easy to prototype, too.

If you need another reason to choose our 6805 family, here it is: they're so easy to prototype with our Piggyback! We have the 68EM05C4 and 68EM05D2 Emulators, custom 40-pin packages that contain the C4/C8 or D2 micros with a Piggyback EPROM socket.

When installed with a 27C64 EPROM, these devices together become functionally identical to a CDP68HC05C4, CDP68HC05C8 or CDP68HC05D2.

Two final points: we'll give you fast turnaround, and a wide variety of packages.

For more information, call toll-free 800-443-7364, extension 22. Or contact your local GE Solid State sales office or distributor.

In Europe, call: Brussels, (02) 246-21-11; Paris, (1) 39-46-57-99; London, (276) 68-59-11; Milano, (2) 82-291; Munich, (089) 63813-0; Stockholm, (08) 793-9500.



GE Solid State

GE/RCA/Intersil Semiconductors

Three great brands. One leading-edge company.

EDN May 12, 1988

*Trademark of General Electric Company, U.S.A., not connected with the English Company of a similar name.



Cynthia Beers
Applications Analyst
Software Productivity Consortium

Niel D. Harding
Software Engineer
Boeing

Steve Hodge
Manager, Silicon Products Group
Racal-Redac Limited

Frank W. Cooper
Manager, ISF Engineering
WESPACE, Division of Westinghouse

Pat Wolfram
Engineer, Design & Analysis
Division, Mentor Graphics

Our workstations are for those with a passion for performance

While some companies sell a lot of computers because they make something for everyone, we sell a lot because we don't.

All the workstations we make, the applications that run on them, and the networking power that unites them with the other computers in your company were created for a select group of people.

Namely the engineers, product designers, software developers and other professionals who demand nothing less than ultimate compute performance.

People who clamor for access to processing power and graphics. Who possess an insatiable

appetite for information. And who can ill afford to endure the delays, limitations and obstacles that typically hinder the effort to attain it.

If you're such a person, you should have an Apollo workstation. For you'll realize the moment its screen is in front of you that the issue of performance is behind you.

An Apollo workstation will grant upon you enough dedicated compute power to keep your imagination charged permanently. Letting you choose from a compatible family of workstation systems whose prices start as low as a personal computer and whose perfor-



Shinsuke Onaka
Seiko Epson Corporation

Lou Horner
VP, Information Services
Chicago Research & Trading Group, Ltd.

Engineered for Performance.

mance extends to that of supercomputers.

These machines will grant you imagery so brilliant you won't want to blink for fear of missing something. With real time two- and three-dimensional graphics that render up to 16.7 million colors at 130,000 vectors per

second. And they'll open your eyes even wider with networking power and elegance.

Every Apollo workstation, from the Series 3000™ Personal Workstation™ to our new Personal Supercomputer,™ functions as a command center from which you have unequalled access to data, processing power, development tools, and applications.

So that every mainframe, minisuper, and microcomputer on your network is at your beck and call.

In a manner almost invisible to you, our workstations show you networking performance you probably thought impossible.

For with the industry's first implementation of Network Computing Architecture,™ they make your multi-vendor network appear as one computing environment.

Letting you run a single application on a network of computers by automatically dispatching portions of a program to the processors most qualified to execute them. And providing the tools to develop and debug code running on different machines.

All while freeing you to create applications, access network resources and even move from one operating environment to another with whatever language, menus and file names you define.

A fact that might inspire you to wonder if we don't engineer our workstations only for you.

Today, there is more than one way to measure computer performance. But when the criteria include processing power, graphics and network computing, nothing measures up to Apollo.



apollo

For more information, call 1-800-323-1846. In Massachusetts call 1-800-847-1011. Or write Apollo, 330 Billerica Road, Chelmsford, MA 01824. Apollo is a registered trademark and Series 3000, Personal Workstation, Personal Supercomputer and Network Computing Architecture are trademarks of Apollo Computer Inc.



PLD 22V10 24-Pin Reprogrammable.
Performance: 25ns.
Low power: 90mA (55mA max "L").
Variable product terms.
User programmable Macrocell.
Up to 22 input terms, 10 outputs.

Why our high performance 22V10 PLD is the market leader:

First, all the great architectural features of the standard 22V10.

Including Macrocell I/O, so one part can be programmed to replace up to 10 different PLD devices, plus many additional logic configurations. Inverted or non-inverted, registered or combinatorial operating modes. As many registers as you want—1 to 10. Synchronous Preset and Asynchronous Reset features. Configurable with up to 22 inputs and 10 outputs. A Variable Product Term architecture lets you easily tailor the 22V10 for high performance in a wide variety of applications, without burdening the product term structure.

And you get the benefit of easy programming, using industry standard languages like CUPL® or ABEL™, standard programmers, or our handy QuickPro™ programming accessory for PC or PC-compatible.

In other words, you get superb flexibility and ease of use. The 22V10 gives you the convenience of PLD design for logic functions in the 500 to 800 gate array complexity. But without the design complexity of gate arrays.

Now add Cypress CMOS leadership and you have the market-leading 22V10.

Blazing performance, with speeds to 25ns combinatorial/33.3MHz registered.

Quarter-Power for cool performance.

Optional windowed versions for the convenience of reprogrammability.

Skinny DIP or surface mount packaging. Greater than 2000V ESD tolerance on every pin, and the ability to tolerate $\pm 10\%$ power supply fluctuations.

No wonder this is such a best seller.

Get the databook that has the information you need on this great part, and you'll have the information you need on ALL our high performance parts.

CMOS high speed SRAM.

CMOS high speed PROM.

CMOS high speed PLD.

CMOS high speed Logic.

This databook, packed with high speed, low power parts, is yours for a phone call.

DataBook Hotline:

1-800-952-6300

Ask for Dept. C42

1-800-423-4440 In CA

Ask for Dept. C42

(32) 2-672-2220 In Europe

(416) 475-3922 In Canada



CYPRESS
SEMICONDUCTOR



EDITORIAL

Time for a public-image boost



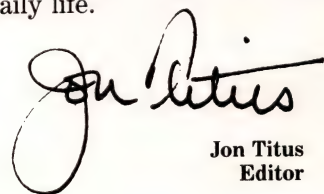
Electrical and electronic engineers should be pleased by IEEE-president Russell Drew's recent call on the Office of Management and Budget (OMB) to review US government contract-award practices. Drew was responding to the publication of terms in a 1987 Navy contract under which a firm was supplying engineers at a \$7.29 hourly rate. That pay rate included the engineers' benefits. In a strong letter to Robert P Bedell, Administrator of the US Office of Federal Procurement Policy, Drew says he wants the OMB to "... ensure that degreed engineers are not receiving unrealistically low hourly rates in other Government contracts."

Drew's letter is a step in the right direction, as is his request that IEEE members report similar "wage-busting" contracts to the organization's US Activities Board (USAB) in Washington, DC, (202) 785-0017. We hope the USAB will listen to nonmembers, too. Exposing such low hourly wages is commendable, but the IEEE must follow through with more than calls for action. Unfortunately, the organization has little power beyond asking Government agencies to enforce hiring directives and policies.

Perhaps some of the IEEE's lack of strength results from the electrical engineer's poor public image. After all, why should anyone worry about an all-but-invisible profession? Few people can describe what an EE does or where such an engineer might work. Drew addresses engineering's PR problem in the April 1988 issue of *The Institute*. For example, he says that although most people perceive outer-space activities as the result of scientific endeavors, they are generally engineering triumphs. So, the IEEE acknowledges the problem, but Drew goes on to say that the organization doesn't know what to do about it.

As a partial solution, Drew suggests that individual members seek media coverage that draws attention to the IEEE and its role in the profession. That's the wrong approach. If people don't know much about engineering, why should they care about the IEEE? Drew's additional suggestions include putting on a presentation about engineering, supporting public-service activities, and getting involved with local education groups. These activities can enhance *your* image, but without a comprehensive plan, they'll do little to enhance the profession's.

So, I'm still wondering why an organization of 290,000 professional members in over 130 countries is calling on individuals to solve a problem it should have tackled years ago. It's time to get a complete electrical- and electronic-engineering PR plan and timetable from the IEEE. The goal must be to make engineers a visible part of society and to tell people what we do, who we are, where we work, why we engineer, and how we affect daily life.


Jon Titus
Editor

"EDN MAGAZINE GREATLY ENHANCES OUR INTERNATIONAL IMAGE."

Phil F. Walters
Marketing Director
Hunting Hivolt Ltd.

Based in England, Hunting Hivolt is a leader in high-voltage technology. Yet the company wanted to further enhance its international image and gain an even greater awareness with engineers and engineering managers worldwide.

What was the answer?

First, set up a facility in the United States. Then support it with an advertising program in EDN magazine. Says marketing director Phil Walters, "The result has been an utter success. The quality of response has helped strengthen our position in

the United States and throughout the many countries where EDN magazine is circulated."

Phil Walters sees EDN magazine as a key element in his worldwide advertising campaign. "With EDN magazine and the solid foundation of Cahners Publishing behind it, we will continue to make strides in the international marketplace."



Advertising in EDN magazine works for
Hunting Hivolt. It can work for you.

EDN

Where Advertising Works

Panorama-Monitor EPM

for the right perspective
in RFI/EMI measurements and radiomonitoring



- Discriminates closely spaced interfering signals
- Displays interference spectra
 - Checks band and channel occupancy



High frequency accuracy through automatic centre frequency
Wide operating range free of intermodulation
Line and battery powering

Write or call for the data sheet **Panorama Monitor EPM**

Compatible with
R & S test receivers
with 75 and 10.7 MHz IF

Models for intermediate
frequencies from 70 to
85 MHz also available

Rohde & Schwarz
Postfach 80 14 69
D-8000 Muenchen 80
Federal Republic of Germany
Telex 523 703 (rus d)
Tel. internat. + (49 89) 41 29-0

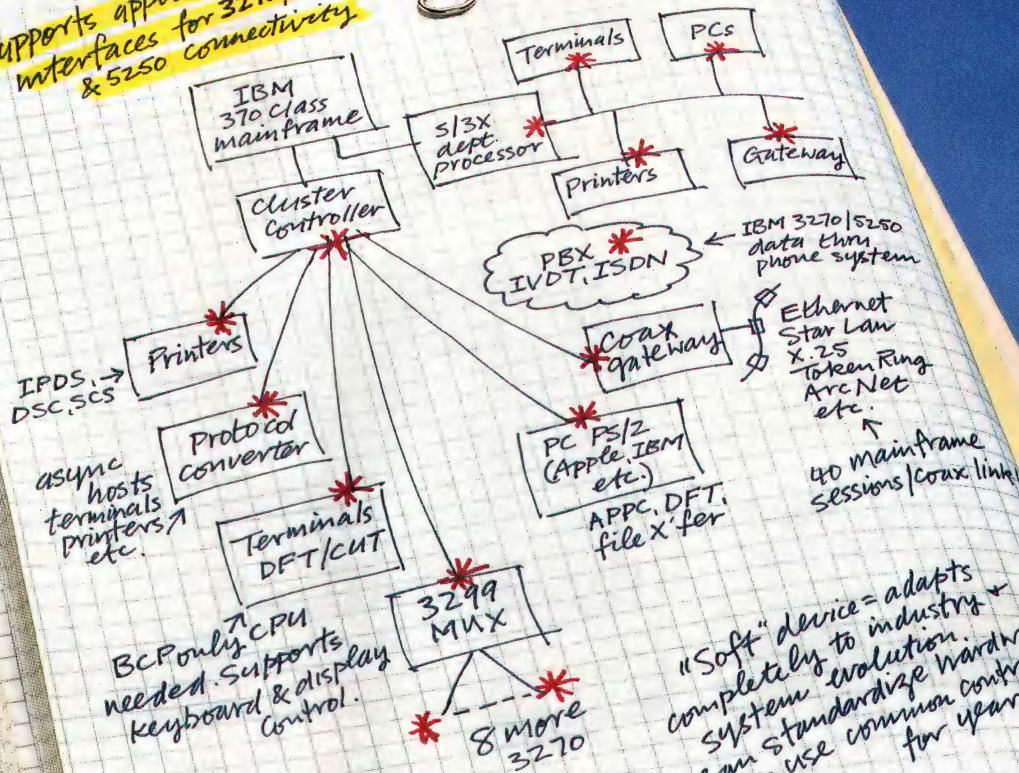


ROHDE & SCHWARZ

CIRCLE NO 179

B-EPM

Supports application
interfaces for 3270/3299
& 5250 connectivity.



*** DP8344
BCP**

Now anyone can draw on the power of the mainframe with a single chip.

INTRODUCING THE DP8344 – THE EASY, AFFORDABLE WAY TO IBM CONNECTIVITY

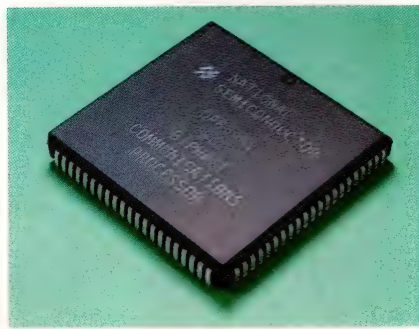
At last there's a one-chip solution to processing IBM 3270, 3299 and 5250 communication protocols – the programmable DP8344 Biphase Communications Processor.

The BCP™ is easily integrated into cluster controllers, PCs, terminals and printers, so now anyone can design a plug-compatible interface for IBM mainframe and departmental processors.

You can also use the DP8344 in a PBX or to build a gateway to various local- and wide-area networks.

You can use it in a protocol converter to give inexpensive peripherals access to the power of the mainframe. Or in a PC or IBM PS/2 to provide 3270 or 5250 terminal emulation.

In fact, providing IBM connectivity is now so simple and inexpensive that a host of new applications are being developed. The BCP has been designed in by more than 100 companies – including Hewlett-Packard, Local Data, Pathway Designs, Lee Data, Centronics, and Memorex.



IT GIVES YOU A LOT OF POWER IN A VERY SMALL SPACE

A full system, supporting all three IBM protocols can be implemented in an area not much larger than a credit card.

The BCP integrates an intelligent transceiver and a high-performance CPU on the same low-power CMOS chip.

Powerful enough to operate as the sole system processor, the BCP also incorporates a flexible bus interface with on-chip arbitration logic, enabling communication with other processors.

With a 20-MHz, 50-nanosecond T-state processor, 30 instruction types, full-function ALU, and an instruction-cycle time ranging from 100 to 200 nanoseconds, the DP8344 supports the 3270 protocol using only 20 percent of the CPU bandwidth.

Fast and flexible interrupt and subroutine capabilities, with on-chip stacks, make the remaining bandwidth readily available for other system tasks. In fact, enough power is available to eliminate other system processors entirely.

IT COULDN'T BE MORE FLEXIBLE

The BCP features a software-configurable transceiver that supports not only IBM 3270, 3299 and 5250 protocols but also general eight-bit protocols.

A simple line interface connects the BCP to the communications line. The receiver includes an on-chip analog comparator and provides a TTL-level input for added flexibility.

WE'LL GIVE YOU ALL THE SUPPORT YOU NEED

The DP8344 is backed by a development package that includes a demo/evaluation board with a monitor/debugger program, in-system emulation features, and demonstration software for complete 3270 terminal emulation on an IBM PC.

On the system level, we offer both 3270 and 5250 controller emulators and analysis tools.

Application support is available through a worldwide network of technical support centers.

For more information on the DP8344 BCP – the easy, inexpensive way for you to provide IBM connectivity – please contact your National Sales Engineer.

Or write National Semiconductor, MS 23/200, P.O. Box 58090, Santa Clara, CA 95052-8090.

 **National Semiconductor**

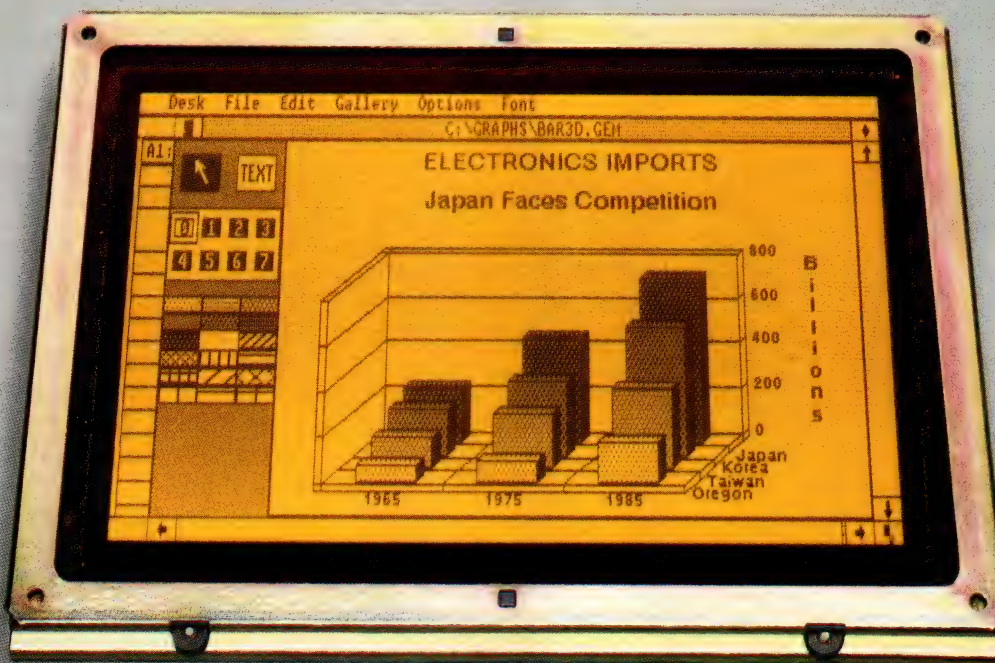
© 1988 National Semiconductor Corporation
BCP is a trademark of National Semiconductor Corporation.
IBM and PS/2 are registered trademarks of International Business Machines Corporation.

Advanced
Peripherals

Display technology is often the last thing you specify.



And the first thing your customer sees.



LCD display and Planar EL display photographed under identical ambient lighting conditions.

From a customer's viewpoint, there's only one real window into your product.

The display.

If it's inferior, your product is judged inferior. No matter how good it really is.

For flat panel displays, there's a simple, yet elegant solution. Planar's electroluminescent (EL) display. Why is EL the preferred display technology? Better viewing angle. Better brightness. Better contrast.

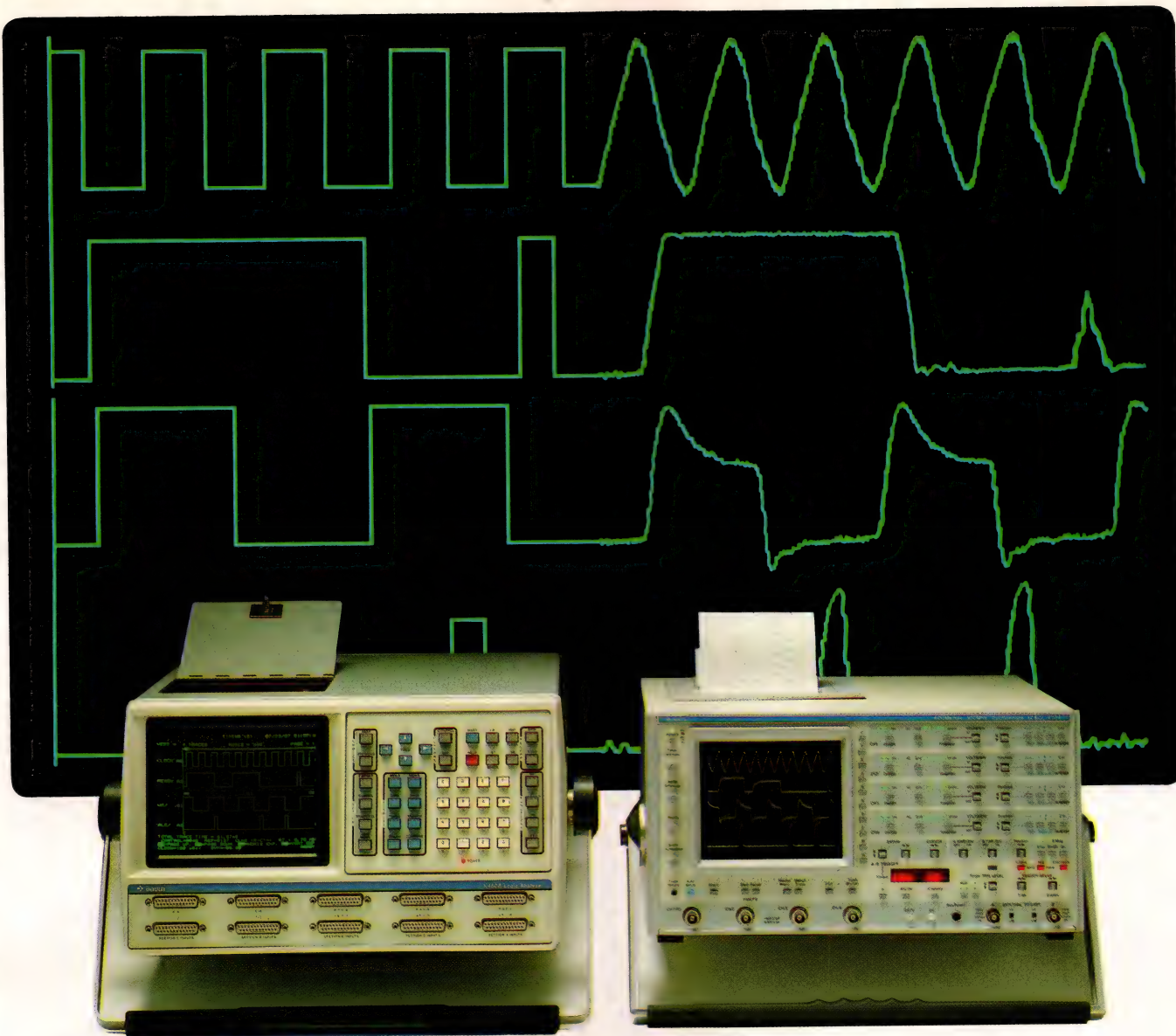
It adds up to superior performance.

So contact us today. Choose the flat panel display that surpasses all others from every one's point of view.

For a brochure, please phone either 503-690-1100 or 503-690-1102, or write to

PLANAR SYSTEMS, INC.
1400 N.W. Compton Drive
Beaverton, Oregon 97006.

PLANAR



The best of both worlds.

The K450B Logic Analyzer and the 4074 Digital Storage Oscilloscope from Gould...

State-of-the-art test instruments for designers of today's superfast digital and data communications systems.

Powerful measurement capabilities...
The K450B Logic Analyzer, with up to 80 channels at 100 MHz or 40 channels at 200 MHz and glitch capture across all channels, provides top performance. AND the 4074 DSO—the only 4 channel instrument with 400 MSample/Sec 8 bit converters on every channel—is the most sophisticated oscilloscope available for the high speed pulse measurements

required by electronics designers and test engineers. TOGETHER—they work as an integrated system without any of the compromises of hybrid systems; APART—two high performance instruments available for separate test applications.

ease of use...

We provide that on both the K450B and the 4074 with our AUTO SETUP facility.

and fail-safe performance!

Gould Electronics created the timing analyzer market in 1978 with the introduction of the first logic analyzer; and we were pioneers in DSO technology. Today we supply leading computer and telecommunications equipment makers with

logic analyzers and DSOs for digital design verification, hardware and software integration, component and sub-system test, hardware debug and digital remote diagnostics.

Wherever high performance test and analysis is required in digital electronics design, Gould is at the leading edge with a price/performance record second to none.

For further details, contact:

Gould, Inc.
Test & Measurement
19050 Pruneridge Avenue
Cupertino, CA 95014
1-800-GOULD 10

 **GOULD**
Electronics

NCR keeps raising the standards for SCSI.

Finally, a cure for SCSI headaches.

NCR's 53C90 is the only chip that can give you fast, fast, fast relief from headaches. Using combination commands, dedicated sequential logic and dual-ranked registers for command pipelining, the 53C90 is quickest on and off the bus. Plus NCR implements complex bus sequencing in hardware, not time-wasting software.

Transfer rates? NCR's 53C90 delivers the SCSI bus maximum of 5.0 MBytes/sec synchronous and 3MBytes asynchronous at 25MHz for the full length of the bus.

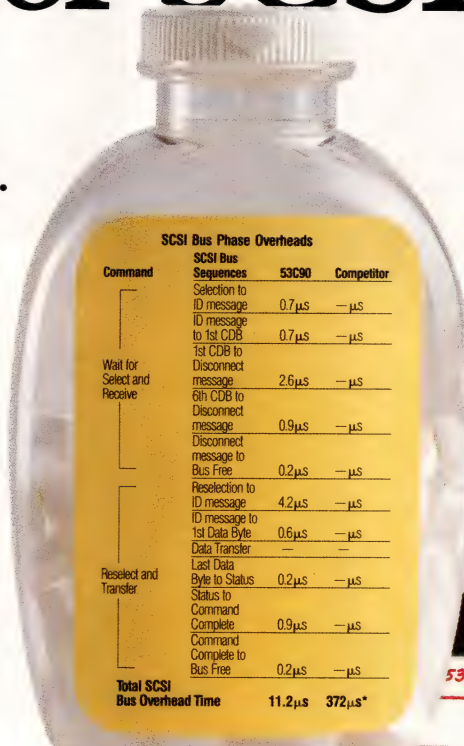
How to get zap-resistance, latch-up protection and the blessings of the FCC.

It's easy.

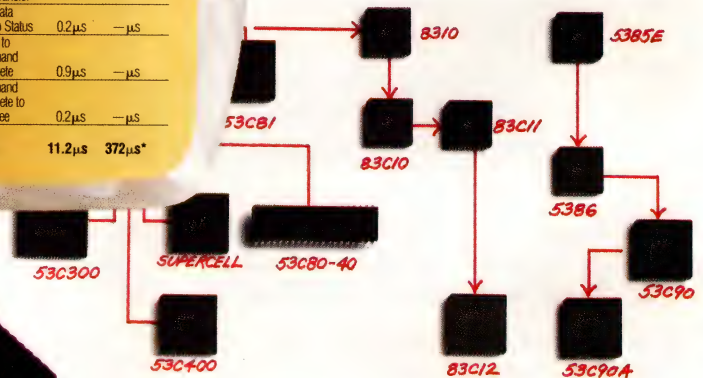
The NCR 5380 and 53C90 families give you ESD protection up to 10,000 volts on the SCSI bus. NCR also provides controlled fall times to reduce the undershoot that could cause other CMOS chips to latch-up. Controlled assertion rates also reduce generated RFI, an important factor in winning FCC approval for the final product.

A big, well-connected family.

NCR's family goes back to the "Mayflower" of SCSI controllers with the 5385 in 1982. The most recent offshoot—the high-performance 53C90A. Other family members include a single chip host bus adapter (53C400), an integrated buffer controller (53C300) and even an ASIC supercell for circuit designers. Plus we'll be there with SCSI II.



Command	SCSI Bus Sequences	53C90	Competitor
Wait for Select and Receive	Selection to ID message	0.7 μ s	— μ s
	ID message to 1st CDB	0.7 μ s	— μ s
	1st CDB to Disconnect message	2.6 μ s	— μ s
	Disconnect message to Bus Free	0.9 μ s	— μ s
	Disconnect message to Bus Free	0.2 μ s	— μ s
Reselect and Transfer	Reselection to ID message	4.2 μ s	— μ s
	ID message to 1st Data Byte	0.6 μ s	— μ s
	Data Transfer	—	—
	Last Data Byte to Status	0.2 μ s	— μ s
	Status to Command Complete	0.9 μ s	— μ s
	Command Complete to Bus Free	0.2 μ s	— μ s
	Bus Free	—	—
Total SCSI Bus Overhead Time		11.2 μ s	372 μ s*



Raise your standards.

Because our chips have an edge in technology, they can help give you an edge in the market. So don't settle for the standard, call NCR today.

For documentation call our hot line 1-800-334-5454. Or write to, NCR Microelectronics, SCSI Products, 1635 Aeroplaza Drive, Colorado Springs, CO 80916.

For technical assistance, call 1-800-525-2252, Telex 452457.



NCR Microelectronics Division

*Electronics Magazine August 20, 1987 Pg. 65

CIRCLE NO 182

EDN May 12, 1988

TECHNOLOGY UPDATE

OS designers consign much of 386's power to writers of applications programs

Charles H Small,
Associate Editor

The designers of the 32-bit 80386 μ P packed the device with so many built-in hardware features to support complex multitasking operating systems that no operating-system designer has yet made use of them all. Consequently, you can exploit the remainder of the 386's sophisticated hardware in your applications programs without the risk of colliding with the operating system.

The 386's μ P designers envisioned an execution environment where a powerful operating system, running at the highest priority level, would completely control lower-level tasks. These lower-level tasks would each run in their own virtual memory spaces and communicate with other tasks through carefully specified and restricted common memory areas.

In addition, the tasks would communicate with the operating system by making function calls through a protected call-gate mechanism. When the operating system relieved one task and gave control of the CPU to another task, a task-switching mechanism would handle the transferral chores with a single command (see **box**, "386 architecture makes OS design easy").

But as yet operating-system designers have actually taken advantage of surprisingly few of these powerful, special-purpose facilities. Even Unix, running on a 386, leaves virtually all the facilities of the 386 at your disposal for your applications. In fact, designers who wish to

embellish existing 386 operating systems by adding features, or those who want to combine several operating systems into one, have ample facilities remaining within the μ P.

OS need not be a mystery

When using the 386's predecessors, applications programmers often clash with the operating system by using μ P features reserved for the operating system. Although the inner workings of operating systems are by and large not well known to most applications programmers, any operating system is, after all, just another program and need not be mysterious.

The code in an operating system runs, generally, when one of four things happens:

- Operating-system call. The application program—or the user directly—requests the operating system to perform a function.
- Exception handling. The application program makes an error that it cannot by itself rectify.
- External interrupts. An external device, one which is not under the control of the CPU, demands attention.
- Timer interrupt. In time-sliced systems, an internal-timer interrupt often initiates a complex series of decisions and actions on the part of the

operating system as it chooses which application program should get the next time slice.

The 386's mechanisms for handling external interrupts and timer interrupts are completely conventional. An external device supplies the 386 with an 8-bit, identifying vector as part of the external-interrupt handshake. The 386 uses the 8-bit vector to find the beginning address of the appropriate interrupt handler in a 256-entry table.

Timer interrupts for time-sliced, multitasking systems generally use the 386's nonmaskable interrupt (NMI). Like virtually every other μ P's NMI, the 386's NMI causes the μ P to jump directly to the start of the timer-interrupt routine using an address found at a predefined location.

The 386's extensive artillery takes aim at the first two jobs of an operating system: providing simple but common functions for applications programs, and handling task errors—or even better, keeping the tasks

The 386's μ P designers envisioned an execution environment where a powerful operating system would completely control lower-level tasks.

from making errors in the first place.

Influencing these two operating-system jobs are three interrelated and unique aspects of the 386: the 4-level hierarchical memory-protection scheme, the segmented and

TECHNOLOGY UPDATE

paged memory units, and the function-calling and exception-handling mechanisms.

What makes Unix a portable operating system is its use of the lowest common denominator of the facilities available in all processors. Consequently, most Unix and Unix-like implementations for the 386 do not use the 386's segmentation and protection facilities other than to set up

one segment for the entire system.

Similarly, other operating-system designers often write their operating-system code in C in order to make their systems portable. C provides no constructs that use the segmentation and protection mechanisms of the 386. In the programming universe that the C language presupposes, the address space is linear and all pointers can

point to any place in the memory. Also, C assumes that all memory is undifferentiated, read/write memory. C compilers, therefore, do not generate code for the 386's protection facilities. So, if you need to set up areas of protected memory under Unix, or any other operating system written in C, chances are that the entire protection mechanism of the 386 is at your disposal.

386 architecture makes OS design easy

The key to understanding how an operating system interacts with your application program when running on an 80386 lies in the address-calculating hardware of this μ P's complex architecture.

Fig A shows the 386's internal registers. This diagram is quite familiar to anyone used to the 8086/186/286 family. In fact, if this diagram were all there was to the 386's architecture, you would be justified in classifying it as just a souped-up 8086. But the 386's address-calculating hardware has hidden features.

Fig B reveals more of the processes. In 8086/186 fashion, the 386 combines, depending on addressing mode specified by an op code, the values in several registers: the value in a base register (from among the general registers); in an index

register (optionally scaled by 1, 2, 4, or 8); and in a displacement register. The sum of these three values is a 32-bit effective address.

Descriptor registers are hidden

The major difference between the 386 and its forebears is the descriptor registers. Unlike the 8086/186, which uses the segment registers' contents directly, the 80286/386 uses the contents of the 16-bit segment registers as pointers. Each of the six selector registers has a descriptor register associated with it. (These descriptor registers are hidden from the software engineer's view.) When an op code designates a 16-bit selector register, the 386 also factors in addresses and attributes from the descriptor register. Thus when you command the CPU to load a selector register, it actually gets a selector-descriptor pair from a table.

A descriptor register holds a wealth of information. It has a 32-bit base address and 16-bit offset that sets the lower and upper limits (in 4k-byte min increments) of the corresponding selector's memory segment. Each segment can encompass as many as 4G bytes or as few as 4k bytes. The 32-bit sum of the descriptor's base address and the effective address is the linear address. (In virtual-memory systems, the page-address section further modifies the linear address to generate the physical address.)

In addition, the hidden attribute fields of a descriptor determine not only the length of a memory segment but also whether the segment is read-only memory, read-write memory, or executable code. Further the attributes specify the protection level of the memory segment. For example, you can set up a segment so that only tasks at a particular protection level can access it or so that tasks at differing levels can share the segment.

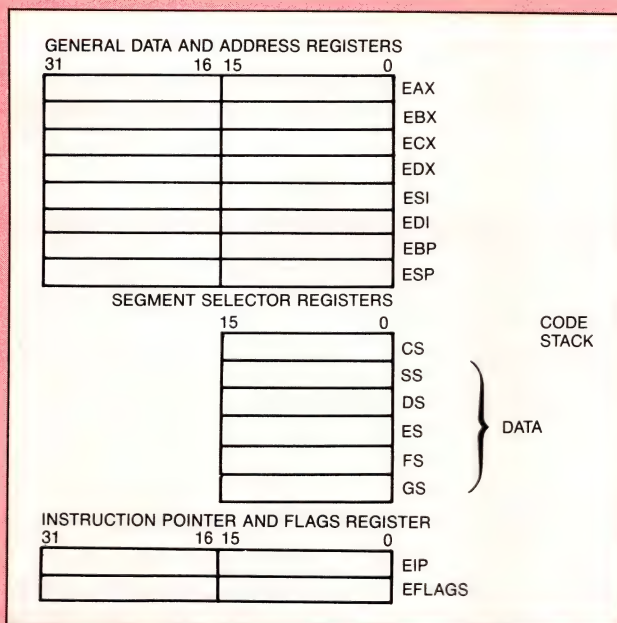


Fig A—The 80386's 32-bit register set bears a superficial resemblance to earlier members of the 8086 family.

TECHNOLOGY UPDATE

Unix also makes no assumptions about I/O. Therefore Unix I/O drivers can use either the general-purpose memory-mapped I/O or the special-purpose I/O space of the 386. Furthermore, Unix does not use the 386's ability to restrict access to I/O facilities depending on a task's I/O priority.

Even Unix System V version 3.1 exploits only two of the four levels of

software protection available on the 386: the Unix kernel at the highest level and all the tasks at the same lower level. Therefore, with the 386, two levels of software protection remain for your use as well.

Paged virtual memory

Because the 386's paging scheme is very similar to the paging scheme of AT&T's μ Ps, however, Unix oper-

ating-system designers have taken advantage of the 386's paging mechanism for AT&T's Unix System V version 3.1, so you can't use it for applications or enhancements at all.

Unix function calls need only minimal CPU support. A Unix function call typically involves loading the function-call identifier and arguments into registers and then calling the operating system through a sin-

The selector-descriptor pairs also effect Intel's call-gate mechanism. With appropriate attribute bits set in a descriptor, a lower-level task can invoke a higher-level routine, such as an operating-system primitive, by using a simple function call. The 386 also uses this call-gate mechanism for task switches, interrupt handling, and software traps. (Similar to a hardware trap, a software trap is an unconditional jump (through a vector) that is activated by an instruction rather than an external interrupt.)

Understanding the call gate mechanism

The call gate appears to the calling task exactly like any other memory area. But when the calling task makes a function call to a memory area designated as a call gate, the 386 automatically

changes the priority level to the level of the called function. When the called function finally returns control of the CPU to the original lower-level task, the 386 automatically resets the priority level. Other μ Ps require you to make a software trap to change priority levels. Only the 386 has this transparent call-gate mechanism.

Note that although any task can invoke a call gate, only a program running at the highest protection level can actually set up a call gate and modify the protection mechanisms inherent in the descriptor; the lower-level tasks can only read tables of selector-descriptor pairs.

The 386 also has an elaborate task-switching facility that saves and restores the entire state of the 386 with a single command.

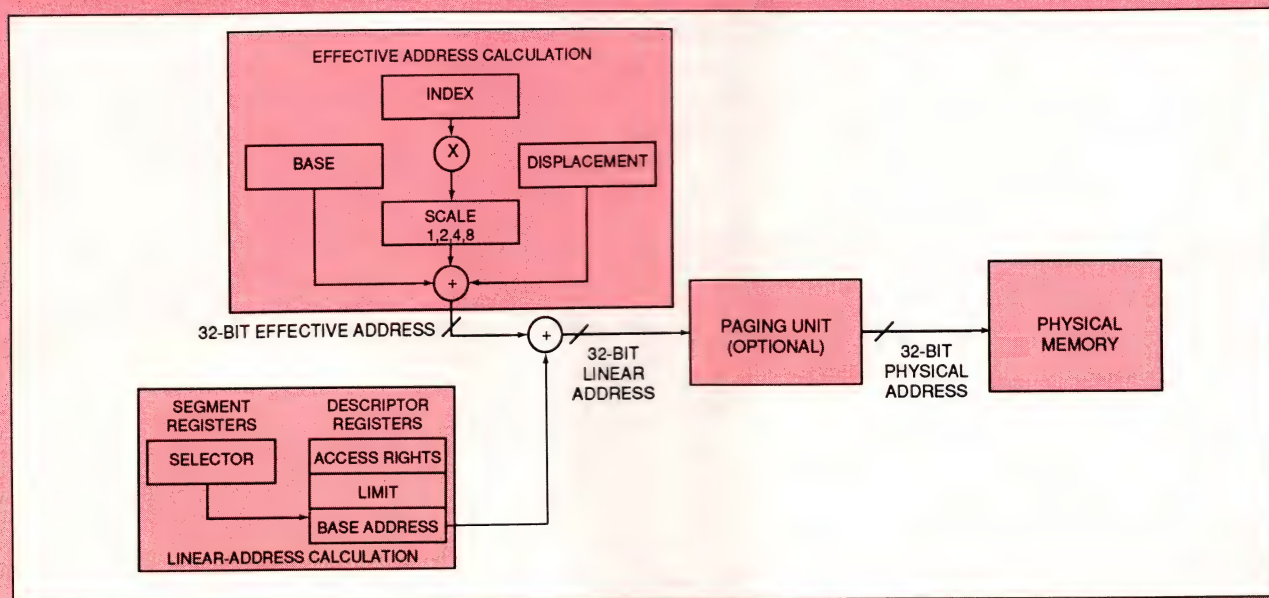


Fig B—The 386's descriptor registers are hidden from the software engineer's view. Each of the six selector registers has a descriptor register associated with it. When an op code designates a 16-bit selector register, the 386 also factors in address limits and attributes in the descriptor register.

gle location. Consequently, 386 Unix function calls use only a single call gate. If you wish to add custom functions to a 386 Unix system, you have plenty of call gates left over to use. Because of its large address range and numerous function-call gates, the 386 can easily contain several operating systems at once.

Real-time systems

Real-time systems such as Intel's kernel version of iRMK, named iRMK, strain the capabilities of the 386 even less than systems like Unix do. Real-time operating-system designers strive to minimize operating-system overhead. Consequently, they tend to place all of the operating-system and applications code in RAM. They also try to minimize the amount of state-dependent information that must be saved when doing a task switch.

Intel's iRMK real-time kernel for the 386 puts all the kernel and task code in a single segment. The kernel and tasks all run at the highest priority level. The tasks make kernel calls with simple function calls—they don't use the task-gate mechanism. The kernel does not use the task-switching mechanism but instead relies on a much simpler software routine to save a task's state when doing task switches. You are

operating system. You can tap their experience when planning your applications programs.

Operating-systems designers applaud the 386's 64-bit barrel shifters for graphics operations. Moving objects on a bit-mapped graphics screen involves reading the screen memory, shifting the bits, and writing the shifted bits back to the graphics RAM. Earlier 8086/186/286 bit-shifting mechanisms cannot handle as many bits as the 80386 can. Consequently, bit-shifting operations in the earlier μ Ps consume multiple CPU cycles. The 386 proves to be at least 12 times faster in this regard than its older siblings.

Operating-system designers also appreciate the 386's built-in breakpoint registers. Other μ Ps merely have single-stepping and software-trap mechanisms for debugging. Using software traps to set breakpoints means that you can break only on instruction fetches. The 386's internal breakpoint registers work more like the word recognizers in the trigger sections of logic analyzers and in-circuit emulators.

In addition to breaking on instruction fetches, these registers can break on reads, writes, or specific data. Often the first evidence of a bad program is corrupted data. Single-stepping and setting software traps only allow you to examine program flow. The 386's breakpoint registers allow you to break execution when they see corrupted data.

Experienced operating-system designers

also suggest that you take advantage of a very useful feature embedded in the 386's companion numerical coprocessor: The coprocessor can remember the identity of the most recent task that did numerical calcu-

lations. If you restrict all your computations to one task, the multitasking operating system never has to save the state of the coprocessor when doing task switches. And not having to save and restore the state of the numerical coprocessor can eliminate considerable overhead.

Cache problems

Operating-system designers do wish that the 386 did not flush its entire cache during task switches. Some of the contents of the virtual memory controller's translation-lookaside buffer (TLB) refer to operating-system program and data that must be present no matter which task is running.

Like the 68000 family, the 386 has single-bit test-and-set instructions. Operating-system designers like these instructions because they can use them to manipulate flags and semaphores in a single CPU cycle. When testing and setting status bits takes several cycles (as it does on most μ Ps), operating-system designers have to suspend interrupts during bit-manipulation operations to insure that the status didn't change while the operating system was checking the status bits. If you are writing real-time or multitasking code, you'll find these instructions can eliminate many of your critical-code lockouts too. **EDN**

Because of its large address range and numerous function-call gates, the 386 can easily contain several operating systems at once.

therefore essentially free to extend the iRMK kernel in any way you wish.

Not all of the 386's facilities that operating-system designers find useful need to be reserved for the

Article Interest Quotient
(Circle One)

High 500 Medium 501 Low 502

WHO YA GONNA CALL TO ICE 68020 BUGS? ATRON BUGBUSTERS!

We recently received a competitive analysis written by a billion-dollar competitor of ours. In it, they rank in-circuit emulation companies in order of importance. We were number one.

SO WHO'S ATRON?

Today, Atron is the number-one supplier of hardware-assisted software debuggers for 8088/80286/80386-based PCs. Nine of the top ten software packages were written by Atron customers. Everybody from AST to Borland to Oracle to Zenith. Now, we can make the same claim in the 68020 marketplace.

Everybody from Apple (MAC IIs) to Wellfleet (datacom) will attest to the superiority of Atron's 68020 debugging technology. One Atron customer even said, "We sent our non-Atron ICE unit out several months ago for repairs; nobody around here seems to know or care if it's back yet. The Atron unit is the tool of choice."

25-MHZ, REAL-TIME, EMULATION: SOONER OR LATER, YOU KNOW YOU'LL NEED IT.

Why invest in a slower emulator (especially one that costs more)? Some bugs only occur in real time, and you know your next design will be 25 mhz. Before Atron's state-of-the-art design, there was no such thing as a 25-mhz emulator. There still isn't another one anywhere near our price.

PROBE CAN TRACE IT THROUGH THE PIPELINE, SO YOU WON'T LOSE YOUR MIND.

The 68020 has an on-board pre-fetch pipeline. Without Atron's 68020 PROBE, your best software engineer will spend a lot of time figuring out which instructions actually execute, and then, which bus cycles go with those instructions. The 68020 PROBE eliminates all these

tedious mental translations and displays what the processor really did. The technology, called pipeline dequeuing, is only available from Atron. Because the Atron bugbusters are the only ones anywhere who've figured out how to do it. And it took us 100,000 lines of code. Consider it our contribution to your sanity. (It was a dirty job, but somebody had to do it.)

68020 PROBE SPECIFICATIONS	
Clock speed	25 mhz
Execution	Transparent
Trace	2048 cycles by 96 bits Qualified trace region Dequeued trace data Pre and center triggered Includes symbols and source Dynamic cache control
Breakpoints	8 hardware on execute Read, write, fetch, logic Single or range addresses 16 software breakpoints Sequential triggers - 4 terms Real-time pass counter Guarded access on memory Output lines for cross trigger Input lines for external logic
Mapped RAM	512K
Source debug	Yes for C, Pascal, Assembler S, Tek, Coff, 4.2 BSD, SUN and IEEE formats
Symbolic debug	Limited only by AT disk size
Symbol table	Multiple windows and menus
User interface	Yes, and conditional execution
Macros	To target system at 375k baud
Download	68881, 68851
Coprocessor	

LET THE SOURCE BE WITH YOU.

Why spend all day doing mental translations between your C source code and the machine code in your target? These tedious operations are eliminated with Atron's source-level debugging capabilities.

Since PROBE uses a PC AT as its instrumentation chassis, you can get compiled code to its target via Ethernet, VAXNet, SUNNet, SCSI or RS-232. And whether you are compiling on a PC, a workstation or a VAX, Atron supports more object-module formats than anybody else (see specification box).



YOU'LL BE A BELIEVER AFTER A SHORT DEMONSTRATION.

So who ya gonna call? Bugbusters! Today. At 408/741-5900. Or send in the attached coupon.

My business card or company letterhead is attached:

- ☐ I've got to see this for myself. Please have a representative call me to schedule a demonstration.
- ☐ Please send me your 36-page 68020 PROBE user's guide, with its command summary and examples of use.

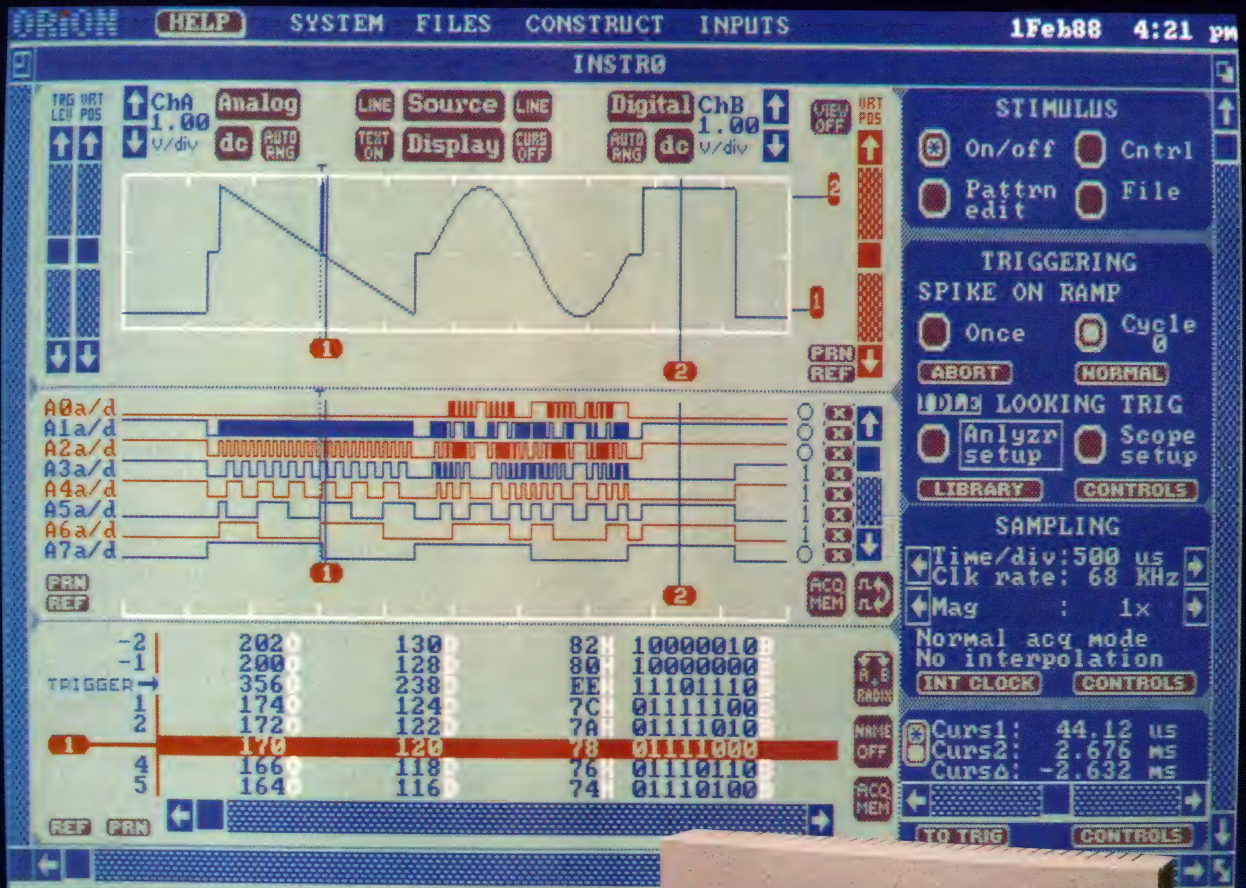


A division of MicroCASE

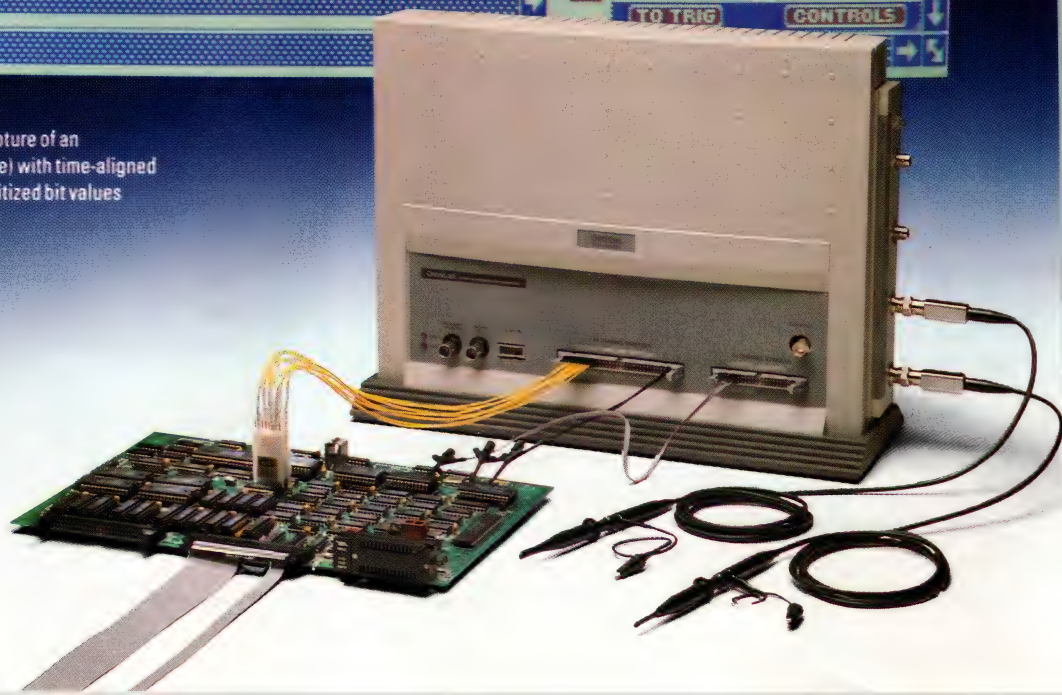
Saratoga Office Center • 12950 Saratoga Avenue
Saratoga, CA 95070 • Call 408/253-5933 today.

EDN051288

NOW, TOTALLY INTEGRATED SCOPE-ANALYZER-STIMULUS TO SOLVE YOUR TOUGH ANALOG AND DIGITAL PROBLEMS.



OmniLab display demonstrates capture of an imbedded analog glitch (in top trace) with time-aligned presentation of the waveform's digitized bit values (center) and numeric states.



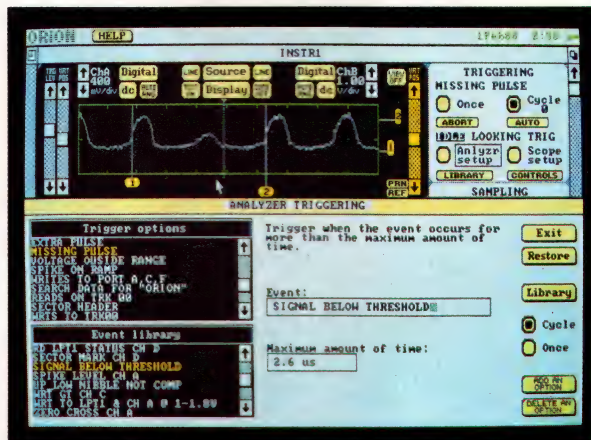
Introducing OmniLab 9240 for interactive analog/timing/state analysis.

■ Combine a 100 MHz digital oscilloscope with a time-aligned, 200 MS/s 48-channel logic analyzer. Next add synchronized analog and digital stimulus generators. Then a remarkable new triggering system. What you have is the 9240 — a whole new class of instrumentation. Expressly designed to speed challenging analog and digital analysis. And get you from concept to product faster.

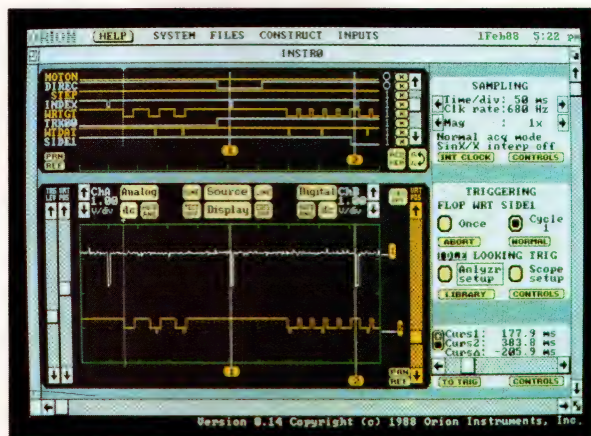
■ The 9240 is based on an innovative new instrument architecture that merges high-speed universal hardware and seamlessly integrated software to create high-performance capabilities not available in separate instruments. Analog and digital traces are always time-correlated in a unique, single screen display. SELECT™ triggering bridges scope and analyzer techniques. And OmniLab's stimulus generators can playback captured or edited signals.

■ At the heart of the 9240 is SELECT triggering, the most straightforward and complete solution ever to triggering dilemmas. It's one system, operating with synchronized analog and digital views of your data. By combining conventional oscilloscope and analyzer triggering with powerful RAM truth tables — plus min/max time qualification as needed — SELECT triggering helps you analyze hardware, debug software, and integrate systems more easily.

■ OmniLab™ is a generation ahead of conventional digital scopes that often hide rarely occurring faults because they only show you a few cycles out of millions. With its continuous monitoring, you can use SELECT triggering to quickly catch every occurrence



SELECT triggering on a rare event. Using Trigger Options and Event Library from the popup panel (at bottom), a trigger is selected to capture a dropout occurring when a disk drive index signal is below threshold for too long.



Logic timing analysis (top) of entire sequence for writing data to a floppy disk. Scope simultaneously displays detailed amplitude and multichannel timing information (bottom).

of rare events like metastable states, bus contentions, missing pulses, and buried noise glitches.

■ The 9240 is like having a complete benchtop of instruments integrated with your PC/AT or compatible. Which you can easily customize for digital development, analog development, or a combination of both.

■ With OmniLab, your productivity will soar. Because you achieve results with fewer instruments. And in fewer steps than ever before. By no means least, the 9240 delivers the best price/performance you'll find anywhere, costing just \$8900 fully outfitted. And most importantly, without compromising a single high-performance spec. Not a one.

■ For more information, call toll free 800/245-8500. In CA: 415/361-8883. Or write for complete literature.

NO-COMPROMISE 9240 SPECIFICATIONS

DIGITAL OSCILLOSCOPE

Digitizers: Two, 8 bit
Bandwidth: 100 MHz
Single-Shot Digitizing: 34 S/s to 204 MS/s
Repetitive Sampling: 680 MS/s
Scale Factor: 5 mV/div to 10V/div in 1-2-5 sequence
Record Length: 4K (16K, 64K optional)

LOGIC ANALYZER

Inputs: 48, timing and state
Asynchronous Clocking: 34 MS/s on 48 inputs; 204 MS/s on 8 inputs
Repetitive Sampling: 680 MS/s on 48 inputs
Synchronous Clocking: 0 to 34 MS/s
Acquisition Memory: 4K samples (16K, 64K optional)
Disassembly Options: Over 150 microprocessors

ANALOG STIMULUS

Output: 8mV to 8 V peak-to-peak, 8 bit
Cycle Length: 4 to 4K samples (16K optional)
Clocking: 34 S/s to 34 MS/s
Functions: Record, edit and playback

DIGITAL STIMULUS

Outputs: 24, 74F tri-state drivers
Cycle Length: 4 to 4K samples (16K optional)
Timing: 34S/s to 34MS/s
Functions: Record, edit and playback

ORION
INSTRUMENTS

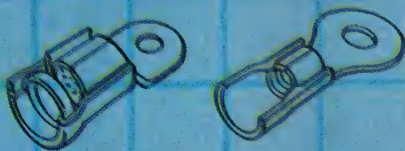
702 Marshall Street, Redwood City, CA 94063
TELEX: 530942 FAX: 415/361-8970

Computer Integrated Instrumentation

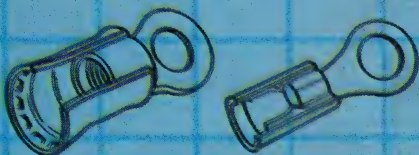
*OmniLab and SELECT are trademarks of Orion Instruments, Inc.

THE CRIMP END

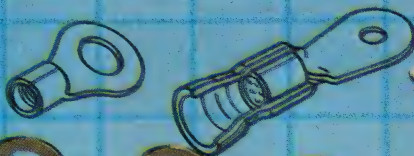
Basic Terminal Material. AMP terminals meet all common standards including MIL, CSA, and UL. High conductivity copper per QQ-C-576, tin plated per MIL-T-10727.



Maximum Contact, Maximum Tensile Strength. Inside of barrel is serrated or dimpled depending on wire size and type of crimp used. Position, depth, etc. are carefully controlled during manufacture. This is a critical part of terminal design.

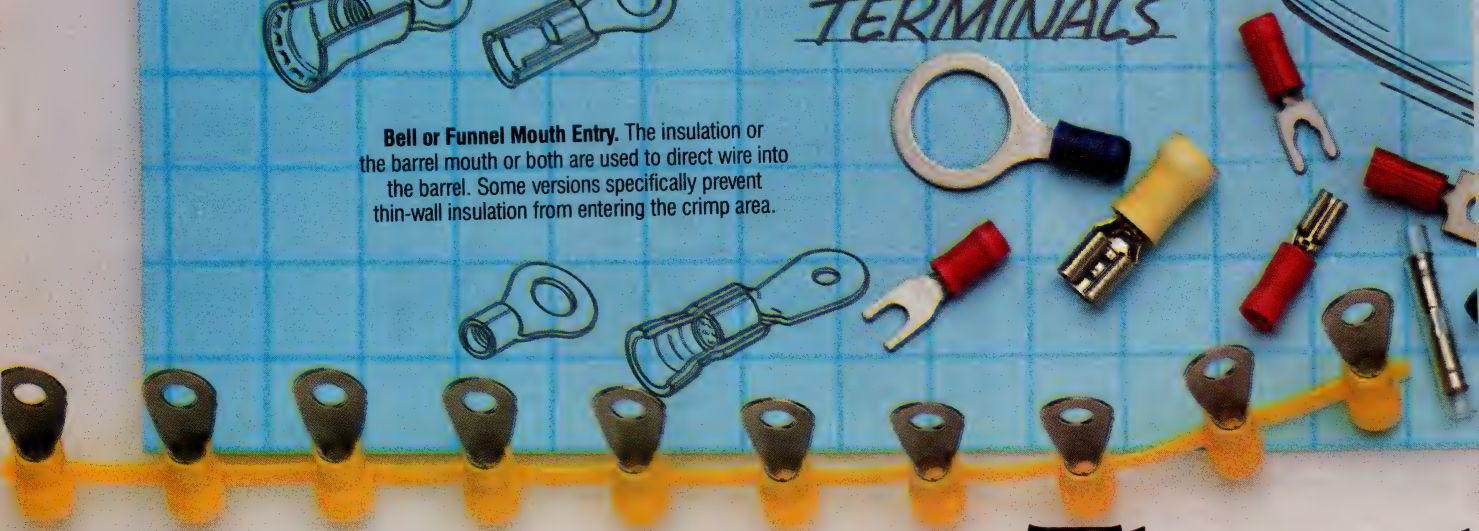


Bell or Funnel Mouth Entry. The insulation or the barrel mouth or both are used to direct wire into the barrel. Some versions specifically prevent thin-wall insulation from entering the crimp area.



Choice of nylon, vinyl, or PVF₂ insulation

TERMINALS



The end

In fact, the terminal you need is probably right at hand.

Our terminals, and our tooling, have always been the standard the rest of the world compares to.

But suppliers get judged, too—on issues as complex as product availability and as simple as responding

to a simple (or not-so-simple) question or two. We know our job when we see it.

Test our reflexes.

Our real job is to be the kind of company you want to do business with.

So we take availability seriously, and make AMP products available the way *you* need them. From worldwide manufacturing and stocking to our nationwide network of AMP Autho-

rized Distributors, we offer the source that suits you.

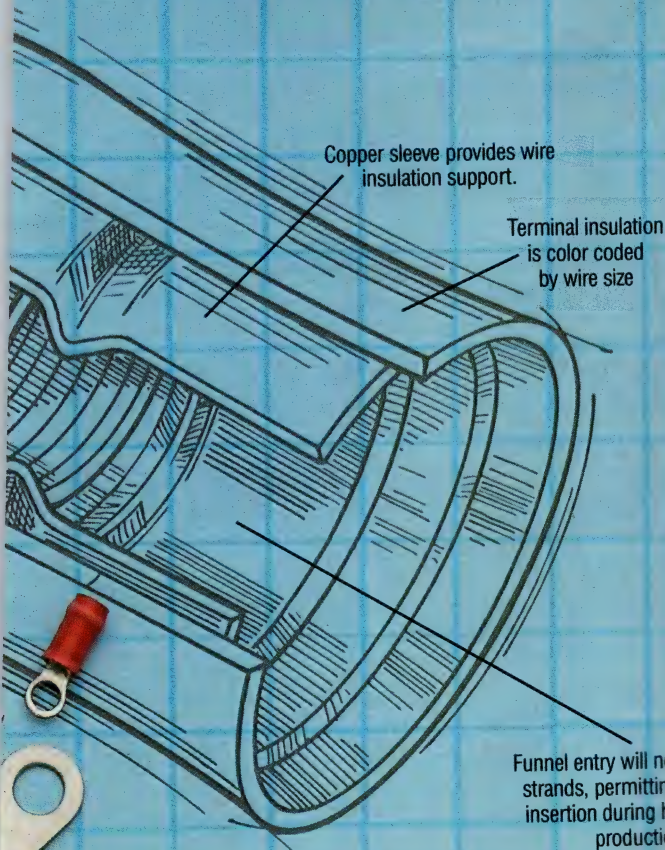
You sometimes need parts in a rush. We've done something about that, too. We've taken our popular industry standard products—including terminals—and stocked up, nationwide.

Your Immediate Shipment Catalog is ready.

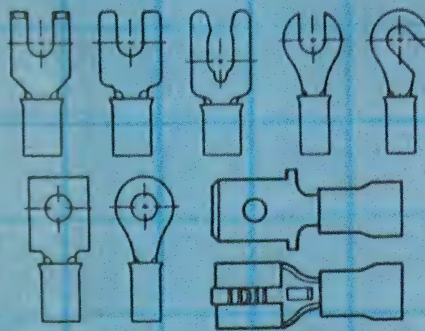
For thousands of products from switches to sockets, terminals to coax, and more, our Industry Standard Products Catalog is almost as good

THE WHOLE TOOLING STORY

Terminal and crimping tool are mated by design and engineered to perform that way. This produces a uniform, certifiable crimp. AMP tooling is available to fit every production rate, and every budget.



Engineering Applied to the End of a Wire. Every termination style AMP offers is available in a variety of tongue types. Overall, we offer ring, rectangular, spade, flanged spade, short and long spring spade, slotted ring, and hook. AMP FASTON receptacles are available in .110", .187", .205", and .250" widths.



THE TONGUE END



More of the Splice of Life. We also offer butt splices, window splices, parallel splices, knife disconnect splices, closed end splices, and spare wire caps.

AMP and FASTON are trademarks of AMP Incorporated.

is nearby.

as a warehouse around the corner.

And you can get your copy just by calling our Information Center and asking for it.

One number to call.

We've consolidated our information systems into a single toll-free number, with hours to cover the business day, coast to coast.

Call us. We can supply product literature. Answer technical questions about any of our catalog products. Guide you to the closest AMP Authorized Distributor.

Any question we can't answer, any problem we can't solve on the spot, will get priority attention. It doesn't matter if your concern is a big one or a little one. Your business matters to us.

For the name and location of your nearest AMP Authorized Distributor, call the toll-free number.

We want to be your supplier.

AMP Interconnecting ideas

1-800-522-6752

42,000 dhrystones with a single
32-bit RISC chip. Sustained.
Seventeen MIPS. Real world MIPS.
25Mhz clock speed. Fifty MIPS by
1991. Blazing fast even
with low-cost memory.



(5x the system speed of the 68030
or the 80386. More than 2x SPARC.)
In CMOS. On the shelf. Now.

Advanced Micro Devices' 29K. The next platform.

ADVANCED MICRO DEVICES. For more information, write "29K" on your letterhead and mail to:

P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS, United Kingdom.

Bruxelles (02-2) 771 91 42 • Hannover area (0511) 73 60 85 • Hong Kong (5) 8654525 • London area (04862) 22121
Manchester area (0925) 828008 • Milano (02) 3533241 • München (089) 41 14-0 • Osaka (06) 243-3250 • Paris (1) 49 75 10 10
Seoul (02) 784-7598 • Singapore (65) 225 7544 • Stockholm (08) 733 03 50 • Stuttgart (0711) 62 33 77 • Taiwan (02) 7122066
Tokyo (03) 345-8241 • Latin America, Fort Lauderdale, Florida/U.S.A. Tel: (305) 484-8600 Tlx: (510) 955-4261 amd ftl.

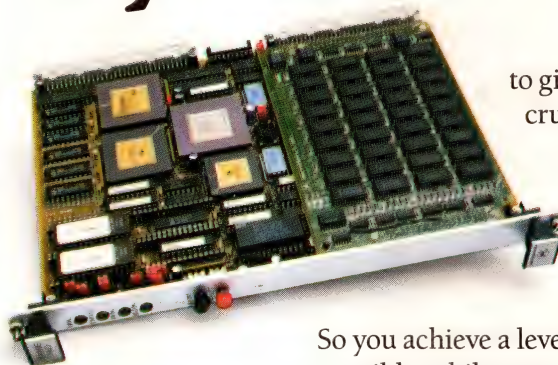
29K logo is a trademark of Advanced Micro Devices. © Advanced Micro Devices, Inc. 1988. 

“Their new 030 board isn't really a single-board computer. It's a single-board system.”

OEMs weren't prepared for the level of *functionality* our new MVME147 processor module delivers. On one standard VME card, it packs virtually all the functions you need to build a small, multi-user system.

How? Mainly through ASICs like the single-chip VMEbus interface and Peripheral Channel Controller. Plus high-density on-board DRAM (4 or 8 Mbytes), SCSI interface and Ethernet chip set. To even come close in functionality, it would take as many as *five* conventional modules.

Besides which, the 147 outperforms everything in sight. It takes maximum advantage of Motorola's new 32-bit MPU—the MC68030—coupled with a floating-point coprocessor. Both running at up to 25 MHz,



to give you outstanding number-crunching power.

And since the 147 features both UNIX® and real-time operating system support, you can plug it into your existing 020-based architecture and software base.

So you achieve a level of integration never before possible, while protecting your existing investment. All of which gives you unprecedented price/performance advantages for just \$3747 in OEM quantities of 100.

To get an idea of what the future of VME looks like, call us today—toll free: 1-800-556-1234, Ext. 230; in California, 1-800-441-2345, Ext. 230. Or write: Motorola Microcomputer Division, 2900 Diablo Way, Tempe, AZ 85282.

UNIX is a registered trademark of AT&T.



MOTOROLA Microcomputer Division

Approaching our technology from your point of view.

Improved voltage-reference circuits satisfy high accuracy and stability needs

Tom Ormond, *Senior Editor*

In the last few years, reference manufacturers have markedly improved device performance. When it comes to accuracy, stability, and thermal drift specifications, today's IC references have truly impressive figures. In all three areas, they easily outperform zener diodes.

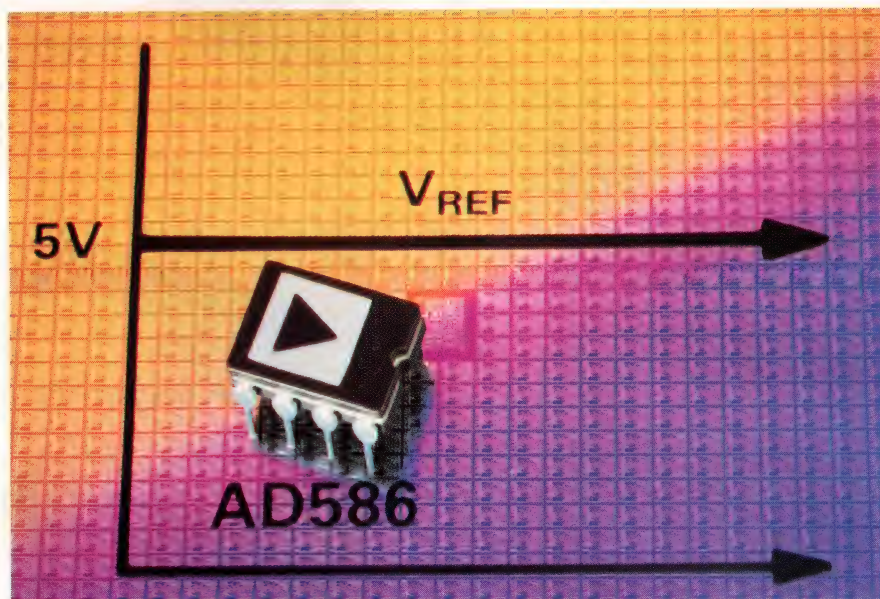
IC voltage references employ one of two technologies—subsurface zener or bandgap. In the first case, a buried zener provides the basic reference output. Typically, this subsurface zener provides very good long-term stability and low thermal drift.

Bandgap references are more complex devices. To generate the reference level, they employ two transistors in combination with the emitter-base diode of a third transistor. As a rule, bandgap references are a little noisier than subsurface zener-type references, but their noise parameters are still very respectable and quite repeatable.

Given this narrow technology base, you might think that voltage-reference choices would be rather limited. Such is not the case, however; you can find a good deal of differences in product offerings. Some references stress low power consumption, and others feature high accuracy and/or stability. You can even opt for programmable references. In fact, you can find references that are essentially application-specific.

Satisfying low-power applications

If you have an application where power consumption is critical, don't despair. Precision Monolithics, Motorola, and Datel all offer references that stress low power consumption.



You can reduce wideband noise to 160 μ V p-p in the AD586 from Analog Devices by connecting a 1- μ F capacitor to the noise-reduction pin. Using one potentiometer, you can also fine-trim the reference value to provide exactly 5.000V or to develop application-specific values such as 5.12V for binary applications.

Precision Monolithic's REF-43, a low-power, precision reference, provides a stable 2.5V output that's impervious to variations in supply voltage, load conditions, or ambient temperature. The device is compatible with any application that requires a known stable voltage and is suitable for use in 8-, 10-, and 12-bit data-acquisition systems, including those that operate from a single 5V rail.

The reference's output voltage and temperature coefficient are both zener-zap-trimmed to ensure a tight 1.5-mV initial output tolerance and a 10-ppm/ $^{\circ}$ C max thermal drift. An internal correction circuit reduces thermal curvature effects that are characteristic of many bandgap references.

Operating with supply voltages from 4.5 to 40V, the REF-43 shows less than 178 μ V of output change over the full supply range—only 2

ppm/V max. The unit requires only 450 μ A of quiescent current and can deliver a 10-mA output current with better than 20-ppm/mA load regulation.

The reference has a temperature output pin that lets you monitor a systems' ambient temperature. You can use this pin to develop a basic overheating indicator or in autocalibration routines.

The REF-43 is available in 8-pin metal cans, ceramic DIPs, plastic DIPs, and 20-contact leadless chip carriers. It comes in two operating-range grades— -55 to $+125^{\circ}$ C (B) and -40 to $+85^{\circ}$ C (F and G). Units processed in accordance with MIL-STD-883 will be available by mid summer. Prices start at \$3.75 (100) for the REF-43GP.

Motorola offers the LM285/LM385 Series, a line of micropower, 2-terminal, bandgap voltage-reference diodes. The references go



"Did you say .025" sq. posts?"

Yes, Samtec offers 95% of all the .025" sq. post interconnects you'll ever need.

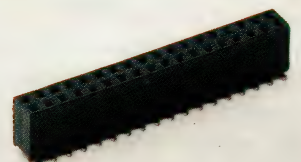
*When it comes to
SUDDEN SERVICE
Samtec really is
a different breed
of cat!*



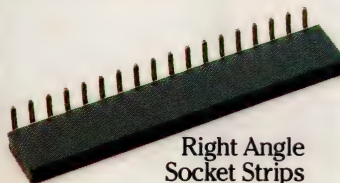
WRITE TODAY
for our new 100-page full
line catalog. It has been
revised and enlarged to
include many new products.
And it contains complete
specification data for fast,
easy ordering. Get yours
today.



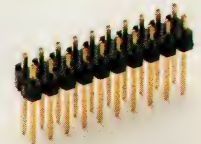
Right Angle Terminal Strips



Surface Mount Socket Strips



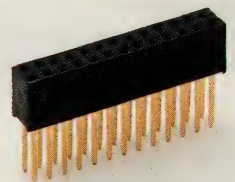
Right Angle
Socket Strips



Dual Terminal Strips



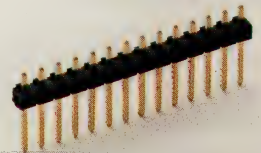
IDC Cable
Socket Strips



Socket Strips



Bottom
Mount Socket Strips



Terminal Strips

For use on board, board-to-board or cable-to-board, Samtec .025" sq. post interconnects provide reliable, gas-tight connections. A unique snap strip feature allows you to snap most strips to desired lengths. **CONNECT TODAY** with Samtec **SUDDEN SERVICE** for all of your .025" sq. post interconnect needs.

samtec

©Samtec, Inc. 1988

**EUROPEAN
HEADQUARTERS:**

SAMTEC, Ltd. 35 Deerdrykes View,
Westfield, Cumbernauld, Scotland G68 9HN
Phone: 02367 39292 FAX: 2367 27113 TLX: 776158

**WORLDWIDE
HEADQUARTERS:**

SAMTEC, Inc. P.O. Box 1147, 810 Progress Blvd.,
New Albany, IN 47150 USA Phone: (812) 944-6733
TWX: 810-540-4095 TLX: 333-918 FAX: 812-948-5047

CIRCLE NO 97

TECHNOLOGY UPDATE

through an on-chip trimming process that tightens initial output tolerances; they feature low dynamic impedance, low noise, and stable operation over time and temperature. Low operating-current requirements make these references suitable for micropower circuitry where extended battery life is a prime design requirement.

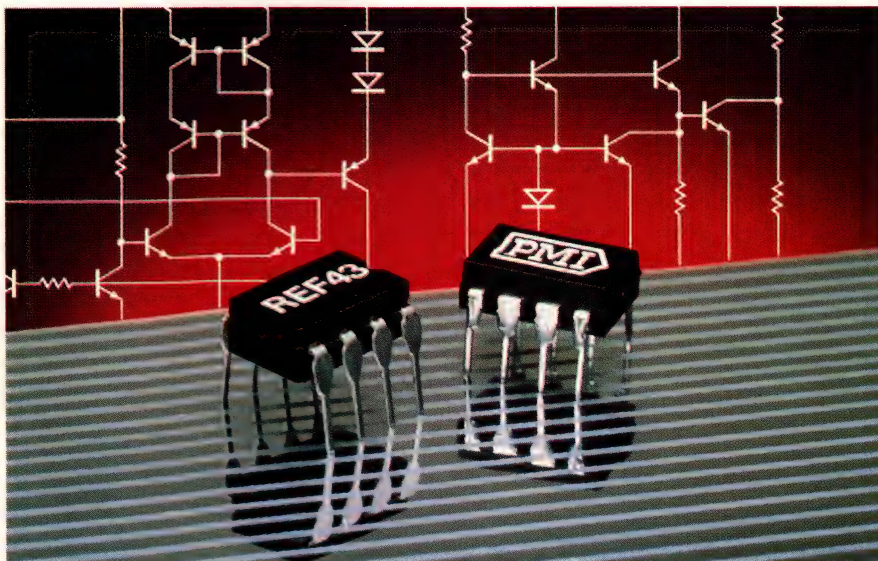
The references are available in two voltage versions (1.235 and 2.500V) and in four initial-tolerance grades (1, 1.5, 2, and 3%). Operating currents range from 10 μ A to 20 mA. Dynamic impedance equals 1%, and wideband noise specs at 60 and 120 μ V rms for the 1.235 and 2.5V versions, respectively. Average temperature coefficient is 80 ppm/ $^{\circ}$ C, and long-term stability measures 20 ppm/1000 hours.

The LM285 and LM385 references are rated for operation over -40 to $+85^{\circ}$ C and 0 to 70° C, respectively, and are housed in TO-226AA (TO-92) plastic packages. Both versions of the LM385 are also available in surface-mountable plastic packages. Prices range from \$1.10 to \$1.45 (100).

Datel's VR-182 Series monolithic bandgap-type devices feature 2.455V outputs. Designed for applications involving A/D and D/A converters that do not have an internal reference, they are also useful in voltage regulator circuits, switching power supplies, comparator circuits, and other analog signal-processing applications.

Maximum reference-current and power-dissipation ratings for the VR-182 devices spec at 120 mA (derated by 1 mA/ $^{\circ}$ C above 25° C) and 300 mW, respectively. Temperature coefficients equal 100, 50, and 30 ppm/ $^{\circ}$ C for Models 182A, 182B, and 182C, respectively. Output tolerance equals ± 35 mV ($\pm 1.43\%$).

An active regulator around the bandgap circuit provides a 0.1 Ω typ dynamic impedance over the 2- to 120-mA reference current range. In addition, the dynamic impedance is flat to 4 kHz, rising to only 1.2 Ω at



A low-power precision reference, the REF-43 from Precision Monolithics Inc requires only 450 μ A of quiescent supply current. It features a 1.5-mV initial output tolerance and a thermal drift of 10 ppm/ $^{\circ}$ C max.

50 kHz. Other specifications include a 10- μ V output noise and 10-ppm/1000-hours long-term stability.

The low 2.455V reference output allows you to use these units with 5V logic supplies. In fact, you can use VR-182 Series references with supply voltages as low as 3.5V. The devices are supplied in 2-lead, hermetically sealed TO-18 packages and operate over 0 to 70° C. The A, B, and C models cost \$0.75, \$0.90, and \$1.05 (100), respectively.

High accuracy is no problem

Voltage references are inherently accurate devices. However, not all available references offer the same degree of accuracy. National Semiconductor's LM169 10.000V unheated precision monolithic voltage reference, for example, has a 5 mV (0.05%) guaranteed initial accuracy—1 mV (0.01%) typ. It also features a guaranteed 8-ppm/mA load regulation and a 3-ppm/V line regulation. It has a guaranteed temperature coefficient of 3 to 10 ppm/ $^{\circ}$ C (depending on device grade) across its entire operating range. The LM169 is characterized and guaranteed over the -55 to $+125^{\circ}$ C military range; the LM369 is characterized for the 0 to 70° C commercial range.

The reference fabrication cycle involves two separate trims—one for V_{OUT} (initial accuracy) and a second independent trim for temperature drift. This dual-trim technique optimizes temperature coefficient figures without compromising the accuracy parameter. Resistor networks are laser-cut (patent pending), rather than shaved or notched, to trim to the correct values. This scheme avoids resist drift problems attributable to electromigration.

The references also have pins available for postassembly trims for both temperature coefficient and accuracy. These pins allow users to compensate for changes in output voltage due to piezoelectric effects on the die from the die-attach or molding process, as well as any shift due to the high temperatures associated with some of the package sealing processes. You can trim the LM169 with a potentiometer in applications requiring additional accuracy. This V_{OUT} trim does not affect the temperature coefficient.

LM369 references are available in four package styles—an 8-pin plastic miniature DIP, a surface-mount SO-8, a 3-pin plastic TO-92, and an 8-pin metal TO-5 can. The LM169 is available in an 8-pin metal can only.

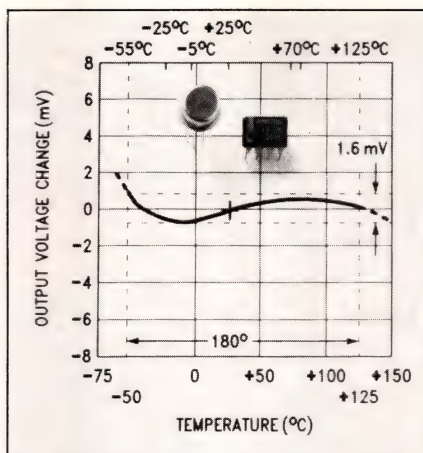
TECHNOLOGY UPDATE

Prices range from \$1.50 (100) for standard commercial-grade models to \$19 (100) for the highest grade military-operating-range versions.

Analog Devices also offers a voltage reference that satisfies high-accuracy requirements. The AD586 5V reference features initial offset error and drift specs as low as 2.5 mV and 5 ppm, respectively. Housed in an 8-pin hermetic ceramic DIP, the unit is suited for operation as a system reference with 16-bit D/A converters, power-supply controllers, and autocalibration systems.

Internal noise-reduction circuitry lets you reduce reference wideband noise by adding a single external capacitor. A proprietary buried zener diode and production laser trimming provide low error, low noise, and high stability over time and temperature.

Typical long-term stability is 15 ppm/1000 hours. Output noise measures 4 μ V p-p in the 0.1- to 10-Hz band and is only 200 μ V p-p to 1 MHz. By connecting a 1- μ F capacitor to the noise-reduction pin, you can reduce this wideband noise to 160 μ V p-p. Using one potentiometer, you can also fine-trim the reference value to provide exactly 5.000V or to develop application-specific values such as 5.12V for binary applications. Total reference-



To optimize temperature-coefficient figures without compromising the accuracy parameter, National performs two independent trims on their LM169 references—one for V_{OUT} (initial accuracy) and one for temperature drift.

output trim capability ranges from -100 to +300 mV.

The AD586's 100- μ V/mA load-regulation capability provides output stability as the load current changes. The device requires a 10.8 to 36V supply level to provide the 5V output. It will supply as much as 10 mA of load current and dissipates 30 mW typ.

The AD586 is available in five performance grades. All versions are supplied in hermetic ceramic DIPs that are compatible with auto-insertion equipment, as well as dice that are tested to commercial-temperature-range specifications. Initial

errors and temperature coefficients range from 2.5 mV and 5 ppm/°C to 20 mV and 25 ppm/°C. References are available with 0 to 70 and -55 to +125°C operating ranges. Depending on grade, prices range from \$2.95 to \$7.65 (100).

Another high-accuracy line comes from Maxim. Its MAX672 and MAX673 monolithic bipolar voltage references are pretrimmed to within $\pm 0.05\%$ of 10V and 5V, respectively. Both references feature tight temperature stability (as low as 5.0 ppm/°C worst case), low current drain (1.4 mA max), and low noise (10 μ V p-p for the MAX673).

Maximum input voltage for both reference families specs at 40V. Typical line-regulation figures range from 0.007 to 0.009%/V, and load regulation equals 0.002%/mA max. In both cases, the regulation figures include the effects of self heating. All units are protected against output short-circuit conditions for an indefinite period.

You can use the trim terminal on the MAX672 and MAX673 to adjust the output voltage over a ± 300 -mV range. This feature allows designers to trim system errors by setting the reference to a voltage other than 10V or 5V, including 10.240V for binary applications. Adjusting this output has no significant effect on the device's temperature performance. The temperature-coefficient change is approximately 0.7 ppm/°C for 100 mV of output adjustment.

The MAX673 also provides a temperature-dependent output voltage on the Temp pin. This voltage is proportional to the absolute temperature and has a scale factor of approximately 2.1 mV/°C. The references are available characterized for operation over three ranges—0 to 70, -40 to +85, and -55 to +125°C. They come in TO-99 and small-outline packages as well as in plastic DIPs. Prices range from \$4.35 to \$10 (100).

Device stability is a key factor when you're evaluating any electronic component. While high initial

For more information . . .

For more information on the voltage references described in this article, contact the manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Analog Devices Inc
Box 9106
Norwood, MA 02062
(617) 329-4700
Circle No 704

Maxim Integrated Products
510 N Pastoria Ave
Sunnyvale, CA 94086
(408) 737-7600
Circle No 707

Precision Monolithics Inc
Box 58020
Santa Clara, CA 95052
(408) 727-9222
Circle No 710

Datel Inc
11 Cabot Blvd
Mansfield, MA 02048
(617) 339-3000
Circle No 705

Motorola Inc
Box 52073
Phoenix, AZ 85072
(602) 897-3842
Circle No 708

Linear Technology Corp
1630 McCarthy Blvd
Milpitas, CA 95035
(408) 942-0810
Circle No 706

National Semiconductor Corp
2900 Semiconductor Dr
Santa Clara, CA 95051
(408) 721-5000
Circle No 709

INTRODUCING FUJITSU'S
NEW 8" DISK DRIVE.

Our best performance numbers yet.

Our new 8" Winchester offers an improved access time of 16ms. 1 GB of storage. And 35,000 hours MTBF.

Three of the best numbers in the business. That's quality. That's reliability. That's the performance you should demand.

And we're delivering production quantities.

We offer multiple interface choices.

HSMD. SCSI. IPI-2.

ESMD. Plus our intelli-

gent SCSI disk controller provides single-ended or differential drivers and Common Command Set support for easy integration.

What's more, our new 8" disk drive has a dual-supported spindle that improves thermal off-track performance. And greatly increases shock tolerance.

So call for more information. On this or any of our famous family of data storage products,

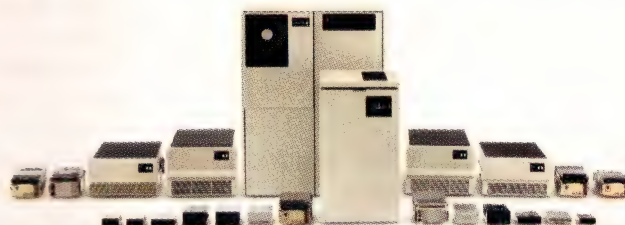
NOW-
1 GIGABYTE
MEANS EVEN BETTER
PERFORMANCE
NUMBERS!!

Model	M2333	M2344	M2372	M2382
Capacity	337 MB	690 MB	823 MB	1 GB
Access Time	20 ms	16 ms	16 ms	16 ms
Transfer Rate	2.46 MB/s	2.46 MB/s	2.46 MB/s	3.0 MB/s
Interface	HSMD/SCSI IPI-2	HSMD/SCSI	HSMD/SCSI	ESMD/IPI-2

including Winchester, tape, optical and flexible drives. 800-626-4686.

Or write Fujitsu America, Computer Products Group, 3055 Orchard Drive, San Jose, CA 95134-2017.

You'll find we have all the right numbers.



A COMPANY WITH CHARACTER AND DRIVE



FUJITSU AMERICA
Computer Products Group

TECHNOLOGY UPDATE

accuracy is an important reference parameter, accuracy vs temperature specs are just as significant. The LTZ1000 voltage reference from Linear Technology Corp is a monolithic IC designed for exceptionally low temperature drift—0.1 ppm/°C typ, 0.3 ppm/°C max. With a long-term drift of less than 2 ppm/month, the reference is aimed at applications such as 7½-digit meters, scales, and voltage calibrators.

The device die includes a 7.2V reference with a temperature compensating transistor, a heater for temperature stabilization, and a temperature-sensing transistor. All the control and biasing circuitry are external to the die to maximize flexibility and long-term stability.

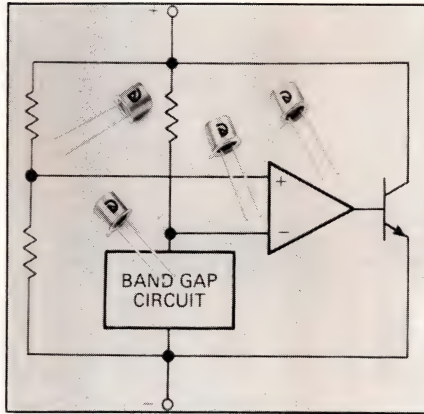
Operating current for the LTZ1000 equals 5 mA, and voltage noise measures 1.2 μ V p-p. Heater resistance specs at 600 Ω , and the buried zener has an impedance (at 5 mA) of 0.2 Ω .

The LTZ1000 has an operating range of -55 to +125°C. In operation, the unit must be shielded from air currents; placing some thermal insulation around the package will optimize reference performance. Optimally, typical stabilized temperature is around 60°C. However, you can operate it at either higher or lower temperatures. Housed in a TO-5 package, the LTZ1000 costs \$35.50 (100).

Programmability adds flexibility

For the most part, voltage references provide one fixed output level. However, some manufacturers offer programmable units that allow you to accommodate various reference-voltage needs. The TL431 and 431A ICs from Motorola are 3-terminal, programmable, shunt voltage references that operate as low-temperature-coefficient zeners. They exhibit characteristics that make them viable replacements for zener diodes in applications such as digital voltmeters, power supplies, and op-amp-based circuitry.

Using two external resistors, you



A 0.1 Ω typical dynamic impedance over the 2- to 120-mA reference current range is a key feature of the VR-132 references from Datal. In addition, the dynamic impedance is flat to 4 kHz, rising to only 1.2 Ω at 50 kHz.

can program the references to output levels ranging from V_{REF} (2.5V) to 36V. The 2.5V reference level makes it convenient to obtain a stable reference from 5V logic supplies. And because the units operate as shunt regulators, you can use them to develop either a positive or negative reference voltage source.

Output voltage tolerance specs at $\pm 1\%$, and dynamic output impedance equals 0.22 Ω . The references have a 1- to 100-mA sink current capability and an equivalent full-range temperature coefficient of 50 ppm/°C; they are temperature compensated for operation over the full operating range.

TL431M models are specified for operation over -55 to +125°C. TL431I and 431AI versions operate over -40 to +85°C, and 431C/431AC models are specified for operation from 0 to 70°C. The references are available in plastic TO-92, plastic DIP, ceramic DIP, and SOP-8 housings. Prices range from \$0.54 (100) for a TO-92 commercial-grade device to \$3.42 (100) for military-temperature-range units housed in ceramic DIPs.

Getting application-specific

Many peripheral devices on the market operate with a $12V \pm 10\%$ supply. In the worst case, the actual supply voltage level could be as low as 10.8V. Lack of operating head-

room makes it very difficult to use a 10V reference under such circumstances. You can go to a lower reference level, of course, but you'll waste a lot of potential resolution.

With an output level of 8.192V, the AD689 from Analog Devices solves this problem. Although this output level might seem unusual, it works out to an even 2 mV/LSB for a 12-bit converter. The device uses a proprietary, ion-implanted, buried zener diode and laser-trimming to optimize initial output accuracy and temperature coefficient.

It also includes the reference cell and an amplifier, which is laser-trimmed for low drift. You can make force and sense connections on both the amplifier output and ground to maintain the accuracy of the reference cell. This scheme allows you to combine the AD689 with boosters to drive long lines or high current loads without degrading reference accuracy at the load.

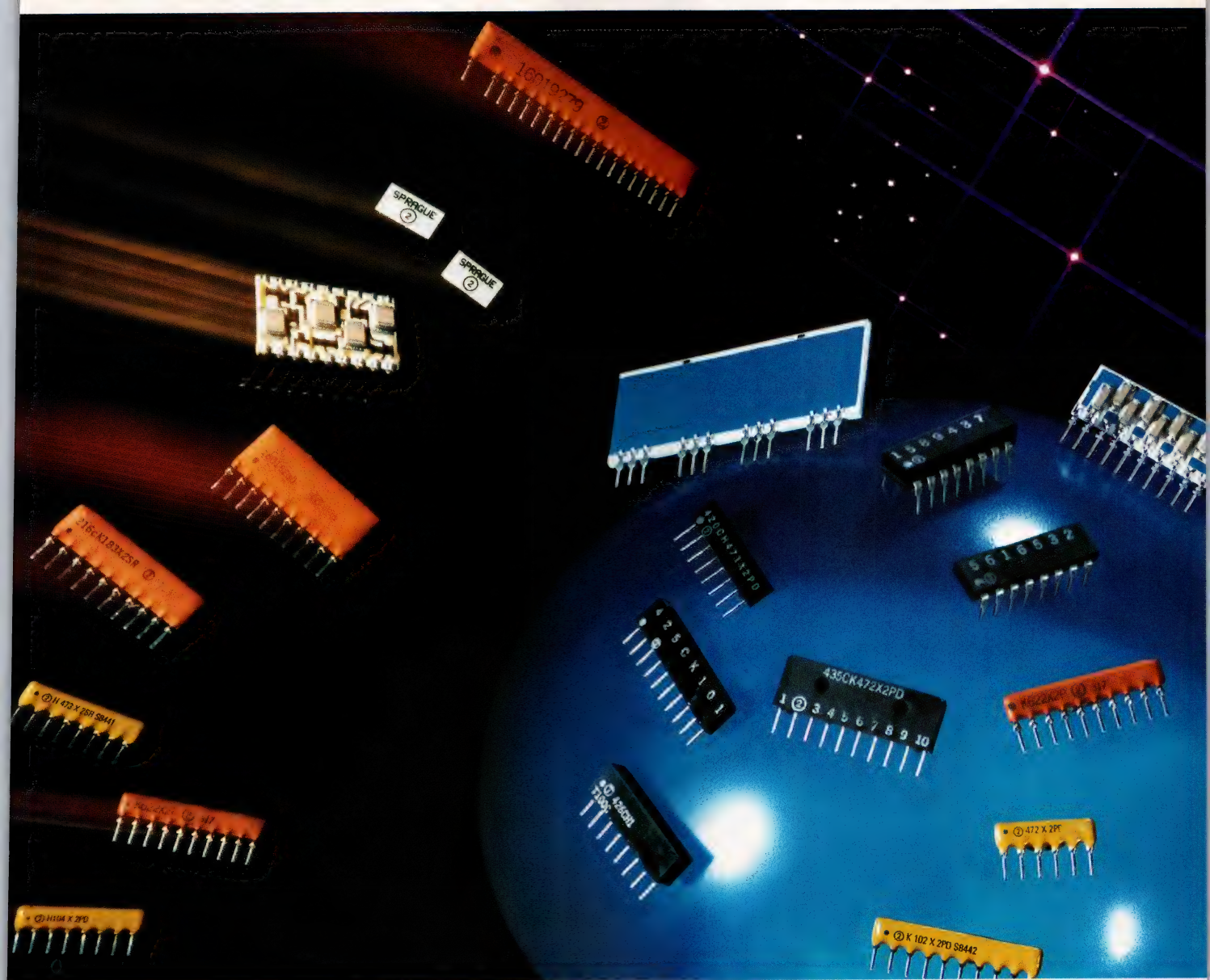
Reference line regulation ranges from ± 200 to ± 250 μ V/V, and load regulation equals 100 μ V/mA. Quiescent current equals 5 mA max, and power consumption specs at 66 mW. Output gain adjustment ranges from -3 to +8%. Output voltage drifts range from 5 to 25 ppm/°C; long-term stability equals 15 ppm/°C. The AD689 has an output noise spec (from 0.1 to 10 Hz) of 2 μ V p-p.

The reference is available in five grades. The J, K, and L versions are tested and specified for operation over 0 to 70°C; S and T units are tested and specified for -55 to +125°C operation. All units are housed in 8-pin ceramic DIPs. The AD689J costs \$2.95 (100). **EDN**

Article Interest Quotient
(Circle One)

High 518 Medium 519 Low 520

THICK-FILM NETWORKS...FAST.



4SR-5125R3

SPRAGUE NETWORKS FOR TOP QUALITY, QUICK DELIVERY.

When it comes to thick-film resistor, capacitor and r-c networks, Sprague means top quality and fast delivery. Anytime. Anywhere. Our precision networks are available in SIPs, DIPs and surface-mount packages. We supply industry-standard parts and custom designs...at competitive prices. Our new catalog covers brand

new products: Type 201C Capacitor Networks, Type 206C R-C Networks, Series 800 Surface-Mount Networks, and molded-case SIP Mil Resistor Networks. For pricing or applications assistance, call our Customer Service Hotline at 603/883-9774. For our Thick-Film

Products Catalog, RN-126A and Supplements, write to: Technical Literature Service, Sprague Electric Company, P.O. Box 9102, Mansfield, MA 02048-9102.



CIRCLE NO 99

National Semiconductor

FAST

1987

FAST Applications Handbook

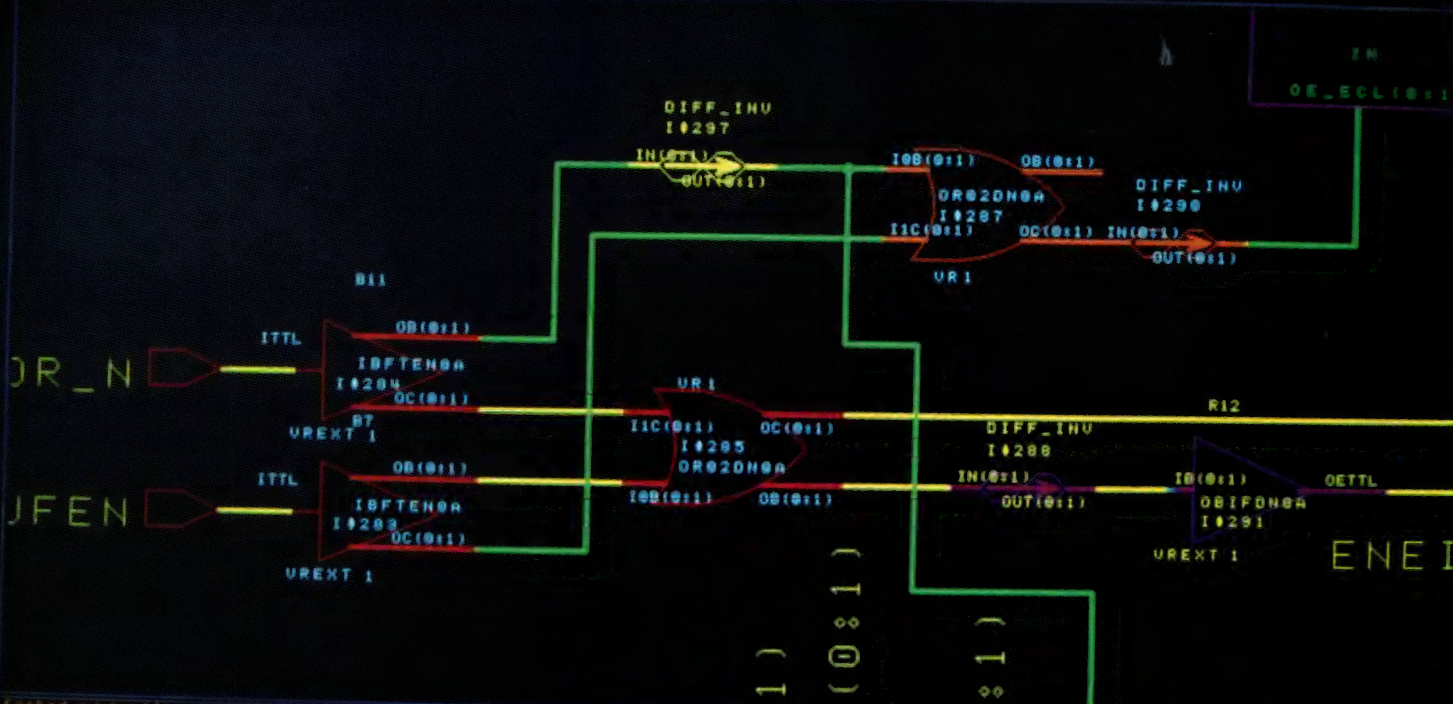
National Semiconductor Corporation

National Semiconductor

FACT

fasted_p/sheet1

edit 0.1 inch Scalable (8.5 X 11.0)



fasted_p/sheet1

context 0.1 inc

FILL  LINE 
 VERTICES SELECTED : 0
 PRIMITIVES SELECTED: 0
 GRID: 0.1 0.1 5
 NO Span Display No Scaling

PICED
 OPEN PICTURE fasted_p -Startup
 VIEW PANEL panel1
 VIEW ALL

The logic in choosing National.

ANNOUNCING A TOP-DOWN COMMITMENT TO FAST AND FACT LOGIC

From design to delivery, no one is doing more than National to meet your advanced logic needs. In fact, no one even comes close.

Only we can offer you the Fairchild tradition of advanced logic technology and applications leadership. Plus our own industry-recognized expertise in manufacturing, packaging, and quality & reliability. All backed by a management commitment to supporting you with service second to none.

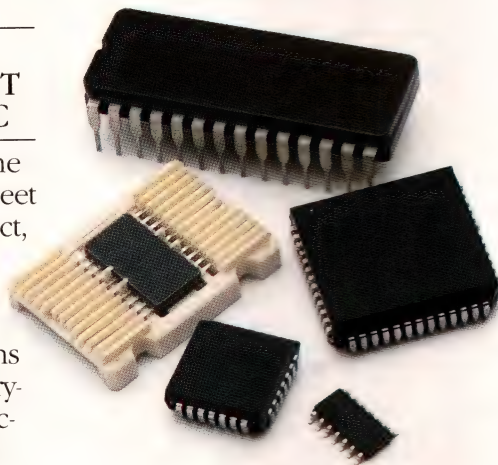
Take a moment to examine the logic of our position.

WE'RE CREATING INDUSTRY STANDARDS

You can expect stepped-up product development in both FAST™ (Fairchild Advanced Schottky TTL) logic and FACT™ (Fairchild Advanced CMOS Technology) logic. Without resorting to padding the lines with seldom-used parts impractical for high-speed logic designs.

In FACT, 77 parts are available today. And we're committing here and now to offer you a total of 150 commercial parts by January 1. Including four LSI functions.

Now think FAST. We've got 135 parts on the shelf right now, 13 of which are LSI functions. 25 new parts will be added to stock by year end.



And we've secured Hitachi and Motorola as world-class alternate suppliers for FACT logic to ensure availability even in peak demand periods.

WE'RE SETTING THE PACE IN QUALITY AND RELIABILITY

We were the first to implement 100% AC, DC and function testing. Our pioneering use of Statistical Process Control techniques from wafer fab through assembly enables us to ship both lines at defect rates of less than 50 ppm.

Our gains in reliability have been equally significant. For example, we process our FACT products with epitaxial silicon for improved latch-up and ESD specifications. The result? The industry's first latch-up and ESD guarantees.

WE'RE LEADING THE FIELD IN MILITARY APPLICATIONS

No other logic supplier offers military customers so many products specifically designed to meet critical mil-specs. Including 77

MIL-STD-883C, 49 JAN Class B and 38 JAN Class S FAST parts. And 23 FACT Standard Military Drawings.

We can supply radiation-tolerant FACT products as well. And we even perform our own radiation testing with an in-house cobalt source.

WE'RE PROVIDING SOLUTIONS IN A VARIETY OF PACKAGES

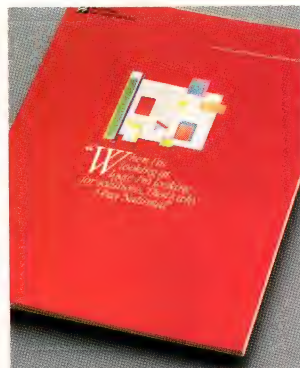
Our FAST and FACT products are available in a full range of package options, including PDIP, CDIP, SO, LCC, PLCC and Flatpak configurations.

WE'RE MAKING IT HAPPEN RIGHT NOW

With fully trained field sales, applications and product specialists located in 46 offices across the nation. A variety of dependable delivery programs from which to choose. And a network of 20 distributors with more than 200 total branch locations.

For details on the logic in choosing National, call today for our latest Advanced Logic Product Status Guide.

1-800-252-4488, ext. 730



 **National
Semiconductor**

©1988 National Semiconductor Corporation

FAST (Fairchild Advanced Schottky TTL) and FACT (Fairchild Advanced CMOS Technology) are trademarks of National Semiconductor Corporation

CIRCLE NO 100

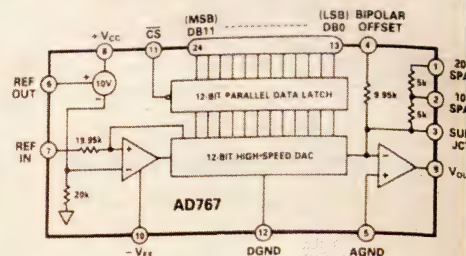


Fast Interface 12-Bit D/A Converter

AD767

FEATURES

Complete 12-Bit D/A Function
On-Chip Output Amplifier
High Stability Buried Zener Reference
Fast 40ns Write Pulse
Guaranteed for Operation with $\pm 12V$ or $\pm 15V$
Supplies
0.3" Skinny DIP Package



AD767 Functional Block Diagram

PRODUCT DESCRIPTION

The AD767 is a complete voltage output 12-bit digital-to-analog converter including a high stability buried zener reference and input latch on a single chip. The converter uses 12 precision high-speed bipolar current steering switches and a laser-trimmed thin-film resistor network to provide high accuracy.

Microprocessor compatibility is achieved by the on-chip latch. The design of the input latch allows direct interface to 12-bit buses. The latch responds to strobe pulses as short as 40ns, allowing use with the fastest available microprocessors.

The functional completeness and high performance of the AD767 result from a combination of advanced switch design, high-speed bipolar manufacturing process, and proven laser wafer-trimming (LWT) technology.

The subsurface (buried) zener diode on the chip provides a low-noise voltage reference which has long-term stability and temperature drift characteristics comparable to the best discrete reference diodes. The laser trimming process which provides the excellent linearity is also used to trim the absolute value of the reference as well as its temperature coefficient. The AD767 is thus well suited for wide temperature range performance with $\pm 1/2LSB$ maximum linearity error and guaranteed monotonicity over the full temperature range. Typical full-scale gain T.C. is 5ppm/ $^{\circ}C$. The AD767 is packaged in a small, 0.3" wide, 24-pin DIP.

PRODUCT HIGHLIGHTS

1. Complete 12-bit DACPORTTM.
The AD767 is a complete voltage output DAC with voltage reference and digital latches on a single IC chip.
2. The input latch responds to write pulse widths as short as 40ns assuring direct interface with the industry's fastest microprocessors.
3. The internal buried zener reference is laser trimmed to 10.00 volts with a $\pm 1\%$ maximum error. The reference voltage is also available for external application.
4. The gain setting and bipolar offset resistors are matched to the internal ladder network to guarantee a low gain temperature coefficient and are laser trimmed for minimum full-scale and bipolar offset errors.
5. The precision high-speed current steering switches and on-board high-speed output amplifier settle within $1/2LSB$ for a 10V full-scale transition in 3.0 μs when properly compensated.

DACPORT is a trademark of Analog Devices, Inc.

Bringing complete 12-bit DAC functionality and



performance to your designs no longer requires having to deal with all the problems associated with external components. Instead, it simply

requires specifying our new AD767 or AD7245.

Both the AD767 and AD7245 feature an on-chip stable buried Zener reference, output amplifier and

microprocessor interface logic. And these complete functions come packed into skinny 0.3" DIPs. All this means you no longer have to deal with error budgets, product characterizations, or space constraints related to external components.

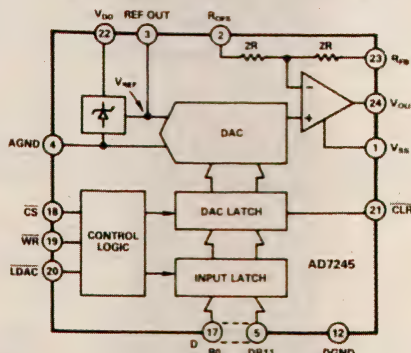
If digital interface speed is what you're after, the AD767 responds to pulse widths as short as 40ns, allowing it to be used with today's fastest processors. On the other

Low Power 12-Bit D/A Converter

AD7245

FEATURES

Complete 12-Bit D/A Function
On-Chip Output Amplifier
High Stability Buried Zener Reference
Low Power (65mW typ)
Single or Dual Supply Operation
0.3", Skinny DIP Package
8-Bit Bus Version Available: AD7248



AD7245 Functional Block Diagram

PRODUCT DESCRIPTION

The AD7245 is a complete 12-bit, voltage-output, digital-to-analog converter with output amplifier and zener voltage reference on a monolithic CMOS chip. No external trims are required to achieve full specified performance for the part.

The part features double-buffered interface logic with a 12-bit input register and 12-bit DAC register. The data held in the DAC register determines the analog output of the converter. The input register data is latched on the rising edge of $\overline{CS}$ and $\overline{WR}$ and data is transferred to the DAC register under control of $\overline{LDAC}$. An asynchronous $\overline{CLR}$ signal on the DAC register allows features such as power-on reset to be implemented. All logic inputs are level triggered and are TTL and CMOS (5V) level compatible, while the control logic is speed compatible with most microprocessors.

The on-chip 5V buried zener diode provides a low-noise, temperature compensated reference for the DAC. The gain setting resistors allow a number of ranges at the output: 0 to +5V, 0 to +10V when using single supply and -5V to +5V when operated with dual supplies. The output amplifier is capable of developing +10V across a 2k Ω load.

The AD7245 is fabricated in an all ion-implanted high-speed linear compatible CMOS (LC²MOS) process and is packaged in a small, 0.3" wide, 24-pin DIP.

PRODUCT HIGHLIGHTS

1. Complete 12-bit DACPORT™:

The AD7245 is a complete voltage output 12-bit DAC on one chip. This single-chip design of the DAC, reference and output amplifier is inherently more reliable than multi-chip designs.

2. Single or Dual Supply Operation:

The voltage-mode configuration of the AD7245 allows operation from a single power supply rail. The part can also be operated from dual supplies to allow a bipolar output range.

3. Low Power Consumption:

CMOS fabrication results in very low power consumption (65mW typical in single supply). This low power allows the part to be packaged in a small 0.3" wide 24-pin DIP.

4. Versatile Interface Logic:

The high speed logic allows direct interfacing to most 16-bit microprocessors. Additionally, the double buffered interface enables simultaneous update of the AD7245 in multiple DAC systems. The part also features an asynchronous $\overline{CLR}$ input.

DACPORT is a trademark of Analog Devices, Inc.

FINALLY, THE COMPLETE STORY ON COMPLETE 12-BIT DACs.



hand, if low power dissipation is critical to your application, the LC²MOS AD7245 consumes only 65mW. There's also an 8-bit bus version of the AD7245 (the AD7248) that loads in two bytes.

To find out how the AD767 and AD7245 can tend to your complete 12-bit DAC needs, contact the Analog Devices office nearest you.



Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; Headquarters: (617) 329-4700; California: (714) 641-9391, (619) 268-4621, (408) 559-2037; Colorado: (303) 590-9952; Maryland: (301) 992-1994; Ohio: (614) 764-8795; Pennsylvania: (215) 643-7790; Texas: (214) 231-5094; Washington: (206) 251-9550; Austria: (222) 885504; Belgium: (3) 237 1672; Denmark: (2) 845800; France: (1) 4687-34-11; Holland: (1620) 81500; Israel: (052) 28995; Italy: (2) 6883831, (2) 6883832, (2) 6883833; Japan: (3) 263-6826; Sweden: (8) 282740; Switzerland: (22) 31 57 60; United Kingdom: (932) 232222; West Germany: (89) 570050

SIEMENS

Integrated protection against
overvoltage, short circuits
and overtemperature:

Smart MOSFETs in SIPMOS technology

Smart SIPMOS® transistors are especially "intelligent" offshoots of advanced SIPMOS technology from Siemens. The prime advantages of this technology – high power switching capability, simple paralleling, fast switching times, linear characteristics (no second breakdown), high current handling and voltage blocking capability plus a storage time of virtually zero – are further enhanced by integrated protective functions and status signaling.

Take the BTS 412 for instance. It's designed for 6–45 V and 12 A, proof against overvoltage, short circuits and overtemperature – and thus practically indestructible. And all this with unbeatable performance and price, because Siemens has made the breakthrough to an entirely new kind of technology. It integrates 5-V CMOS, High-volt CMOS and bipolar structures with Vertical Power MOSFETs and without elaborate junction or dielectric isolation. Thus the way is open for intelligent, digitally driven power switches, which will take on great significance in, for example, the automobile of the future.

Revolutionize your circuits. Delivery of SIPMOS components is fast and dependable.

Siemens AG, Components Group,
Balanstrasse 73, D-8000 Munich 80

TopTech Components: Siemens

CIRCLE NO 103

12/Z031e





SIPMOS



The VME Volksclosure. \$995. Ready to Run.

Finally. The economies of mass production catch up with VME and Multibus II enclosures.

Introducing the Volksclosure, Electronic Solutions' economy model enclosure with turbo performance. All you do is add cards and peripherals for a complete, attractive desktop computer.

With the Volksclosure (also known as our Model One) everything comes standard: six VME or Multibus II slots, space for three half-height 5 1/4" disk drives, and a high-performance six-layer backplane all in a highly tooled enclosure with our handsome front panel that hides those ugly connectors and cables.



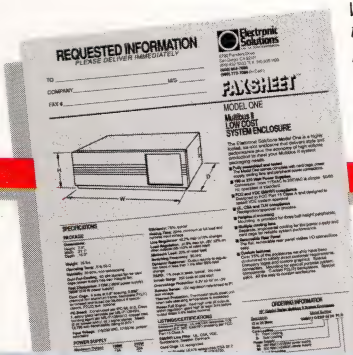
You do get a choice between two multiple-output power supplies: 190 Watts with 19A at +5V or 270 Watts with 30A at +5V. You can also choose a J2 backplane for VME extended addressing or iLBX II for a Multibus II system.

Most important, while the Volksclosure costs less, you don't get less. It fully reflects Electronic Solutions' commitment to quality and performance. For example, it meets UL and CSA safety standards and FCC Class A EMI/RFI specs to the letter.

The New Volksclosure. How to get a lot more mileage from your packaging budget. Call right now for complete details.



We'll FAX you the facts



Want the latest data in a hurry? Nothing is faster than Electronic Solutions' new "FAX the FACTS" program. If you have a FAX machine, just call our "800" number, give us your FAX number and type of FAX machine, and the information you need from us. We'll FAX it to you immediately.



Electronic Solutions
UNIT OF ZERO CORPORATION

6790 Flanders Drive, San Diego, CA 92121 • (619) 452-9333 Telex 11(TWX): 910-335-1169

Call Toll Free: (800)854-7086 In Calif: (800)772-7086

CIRCLE NO 104

EDN May 12, 1988

PC-based CAE software supports large memories and high-resolution displays

The Workview 2000 and 3000 CAE software packages transcend the usual limitations of IBM PC-based design software by breaking the MS-DOS 640k-byte memory limit and by supporting high-resolution video-graphics cards and displays. In fact, the company says these products bring the capabilities of the workstation to PCs, performing schematic capture, analog and digital simulation, and local-area-network communications tasks.

Workview 2000 runs on 80286-based computers and can use as much as 16M bytes of RAM. Workview 3000 runs on 80386-based machines and takes advantage of as much memory as you can stuff into your computer (to the processor's 4G-byte limit).

Both Workview 2000 and 3000 in-

clude the schematic-capture, simulation, waveform-processing, documentation, and network-communications tools offered in the company's earlier CAE products. In addition, the vendor has added a pre-placement capability, which lets you create a file of your preferred component placement for later reference by the pc-board layout designer. Using this option, you can incorporate your knowledge of critical nodes—nodes that might be sensitive to delays caused by long trace lengths—into your design documentation. Workview does not, however, include a module for performing full pc-board layouts. Instead it passes net-list and pre-placement information on to pc-board layout packages from other vendors.

A database manager named

Viewfile acts as a schematic librarian, giving you more control over design changes. Viewfile performs the same functions for schematics and related design documents that source-code librarian or version-control software provides for software projects. The module allows you to group schematics together in sets, to store these sets, to lock sets so they cannot be accessed, and to mark sets for viewing only, thus preventing unauthorized modifications.

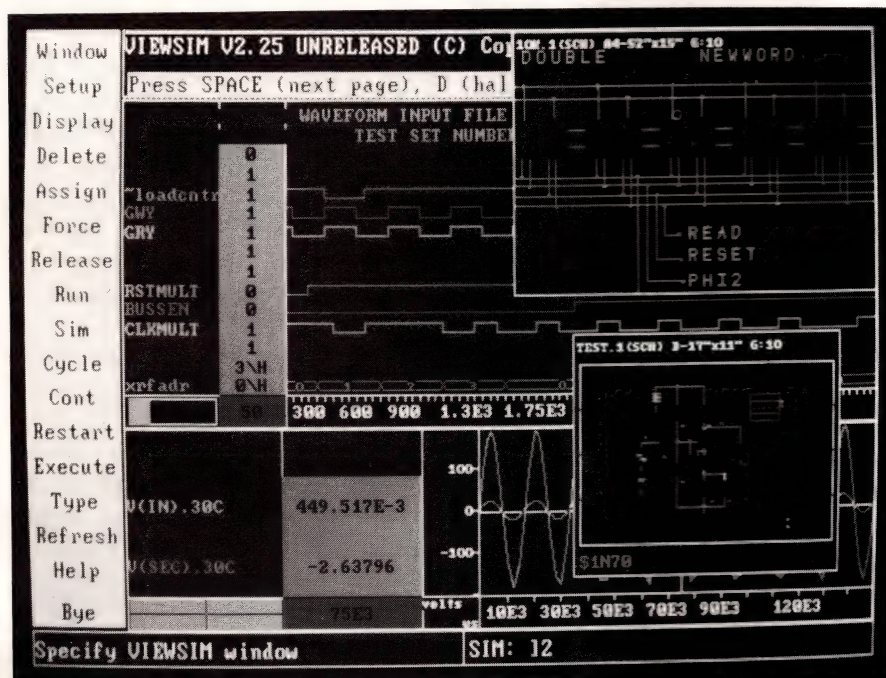
The new versions of Workview also incorporate support for the T4 graphics display card from Microfield Graphics Inc (Beaverton, OR) plus the VGA and 8514/A display cards, which are both from IBM. Using the T4 or 8514/A, Workview 2000 and 3000 can create 1024×768-pixel displays.

Previous versions of Workview used the XNS network communications protocol. The new versions of the package can also handle the TCP/IP networking protocol. In addition, the company has added support for the EDIF (Electronic Design Interchange Format) Version 2.0.0. Workview 2000 and 3000 cost \$10,000 and \$14,000, respectively, and will be available next month.

—Steven H Leibson

Viewlogic Systems Inc, 275 Boston Post Rd W, Marlboro, MA 01752. Phone (617) 480-0881. TLX 174242.

Circle No 700



Support for 16M to 4G bytes of memory and high-resolution displays makes the Workview 2000 and 3000 CAE packages for the PC competitive with workstations, according to the vendor.

CMOS EPROMs feature in-circuit electrical erasing and reprogramming

If you need to update your EPROM-based code or data tables periodically, the 27F64 and 28F256 flash memories are 64k-bit and 256k-bit devices, respectively, that may fit your requirements. Each model lets you erase the memory in full and reprogram it in circuit—all within a few seconds.

Flash EPROMs are similar to EEPROMs in their ability to serve as alterable, nonvolatile memories. You program them one byte at a time. But, unlike EEPROMs, you erase the entire memory at once. In this respect they are more like conventional UV-EPROMs than EEPROMs. Although they are called EPROMs, you do erase flash memory electrically, thus securing simple and reliable in-circuit erasure in less than a second.

Both models are organized as byte-wide memories. The 27F64 is a direct socket replacement for JEDEC standard 64k-bit EPROMs. The 28F256, intended for new designs, has a 32-pin configuration, which is an extension of the JEDEC standard for 256k-bit devices. This extension lets you design a board that allows later EPROM replace-

ments (to 2M bits) without any redesign.

You control the EPROMs' operations by writing commands into their control registers. The commands include setting the device to a read-only state, activating the erasure of the entire device, verifying byte erasure, programming a byte, or verifying the programming of a byte. These EPROMs are designed to safeguard against unintentional programming and erasures: You must issue the program or erase command twice, once to enable the command and the second to activate it.

These devices also incorporate other safeguards. They default to the read-only state at power-up and reset to the read-only state if you bring the programming voltage below 7V. If you hold the programming voltage below 7V, the erase and write functions are disabled and either device continues to operate as read-only memory. A reset command safely terminates an enabled erase or program command.

There is a limit on the reprogrammability of these flash memories: The company specifies that they can

withstand a minimum of 100 erase/program cycles, exhibiting a failure rate less than 0.01% within that cycle range.

Neither the program nor erase commands stop on their own. Once you activate a command, you must issue either a reset or verify command to stop the process. The results of issuing these commands are cumulative, so that a series of short intervals between either a program or erase operation has the same effect as a single long interval. This feature helps minimize total programming time. It typically takes 100 μ sec to program one byte.

Both devices operate at 5V and have a separate input pin for the programming voltage (V_{PP}). Both models are also available in two versions: One has a programming voltage of 12V, the other, 12.75V (the latter gives you erase and programming rates that are two times faster).

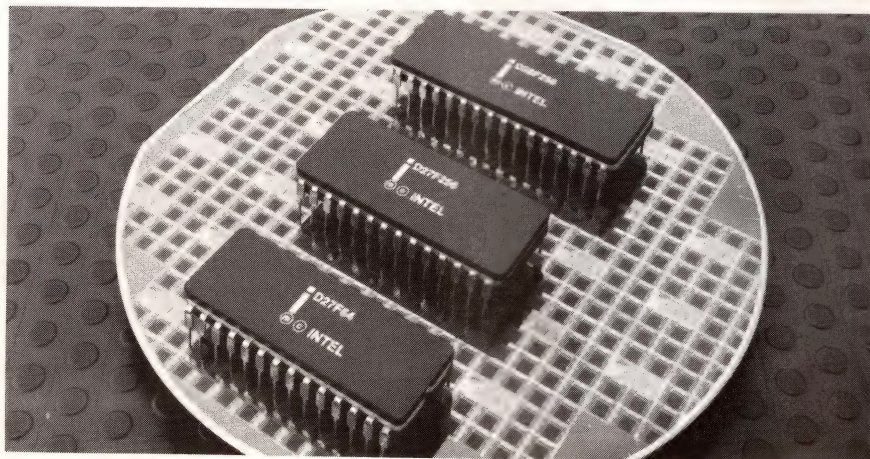
While you are erasing or programming these EPROMs, you must provide 30 mA at both supply and programming voltage pins. The demand at the programming voltage pin drops to 200 μ A during read operations.

You can order these devices with a variety of speeds. The 28F256 has speeds of 170, 200, and 250 nsec. The 27F64 has access times as fast as 150 nsec.

Both devices come in windowless, ceramic DIPs. The 28F256 is also available in a 32-lead plastic leaded chip carrier. The 250-nsec version of the 27F64 costs \$8; the 250-nsec 28F256 is available for \$19.90 (10,000). —**Richard A Quinell**

Intel Corporation, 3065 Bowers Ave, Dept W-424, Santa Clara, CA, 95051. Phone (800) 548-4725.

Circle No 701



You can electrically erase these CMOS EPROMs and reprogram them in circuit. Erasure requires less than a second. Reprogramming takes an average of 100 μ sec/byte.

KILLER I/O

The Z84C90: Two serial, three parallel ports and a counter/timer on one chip. Just think what you can do with it.

Zilog's Z80 SPCT, Killer I/O," gives you a true "System on Silicon." With all the advantages of CMOS technology, Superintegration," and proven Z80 performance. Think of it as the door to a whole lot of new opportunities.

The Z80 Family: Still growing strong.

The Z80 remains the most commonly used 8-bit microprocessor in the industry. No wonder. As the family has continued to develop, so have the advantages: the familiarity of working with devices you know and trust, the tremendous value of being able to use software you've already developed, and, of course, there's the impressive Z80 performance.

As the Z80 Family has evolved through NMOS, CMOS, high-performance and high-integration, our commitment to Z80 has never wavered. New products have continued to be developed. Besides the 16-bit Z280 and the new Z84C90—the Killer I/O—there are a few more you really ought to look at:

- ▶ **Z84C80/81** Z80-based systems GLU logic that can be used in every Z80 application
- ▶ **Z80180** the Z180 8-bit MPU combines a Z80 CPU, MMU, 2 UARTs, DMA, a C/T and more, with no extra logic needed for Z80 peripherals
- ▶ **Z84C01** combines a Z80 CPU with an on-board oscillator

Lots of I/O.

You're simply not going to get more serial/parallel I/O anywhere. We've put together the most popular combination of discrete devices . . . two independent synch/asynch serial channels, two independent parallel ports, an 8-bit programmable port and four counter/timers. And, since they're all fully compatible with PIO, SIO and CTC devices, you have the advantage of "commonality."

Lots of performance.

Superintegration and CMOS technology mean the Z84C90 provides plenty of performance and flexibility. 8 MHz speed for instance. Plus you've got four independent counter/timers and on-chip oscillator to work with. And the peripherals can be used in any combination you need.

Lots of benefits.

You're designing with a highly integrated chip. And you're working with the familiar software and proven performance of the Z80 Family. That's enough to make the Killer I/O the best choice. But think about the lower cost you get from less real estate, lower manufacturing cost and reduced inventory. Think about improved time to market. Or the higher performance and reliability that come with super integration. And it's all off the shelf and backed by Zilog's proven quality.

So whether you're upgrading existing designs or looking for solutions in new applications like cellular phones, personal computers, industrial control, or data communications, you owe it to yourself to contact your local Zilog sales office or your authorized distributor today. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.

Right product. Right price. Right away. **Zilog**

ZILOG SALES OFFICES: CA (408) 370-8120, (714) 838-7800, (818) 707-2160, CO (303) 494-2905, FL (813) 585-2533, GA (404) 923-8500, IL (312) 885-8080, MA (617) 273-4222, MN (612) 831-7611, NJ (201) 288-3737, OH (216) 447-1480, PA (215) 653-0230, TX (214) 231-9090, CANADA Toronto (416) 673-0634, ENGLAND Maidenhead (44) (628) 39200, WEST GERMANY Munich (49) (89) 612-6046, JAPAN Tokyo (81) (3) 587-0528, HONG KONG Kowloon (852) (3) 723-8979, R.O.C.: Taiwan (886) (2) 731-2420, U.S. AND CANADA DISTRIBUTORS: Anthem Electric, Bell Indus., Hall-Mark Elec., JAN Devices, Inc., Lionex Corp., Schweber Elec., Western Microtech., CANADA Future Elec., SEMAD.

"EDN MAGAZINE HAS BEEN A CONSISTENT WINNER FOR THE SGS BRIGHTER POWER CAMPAIGN."

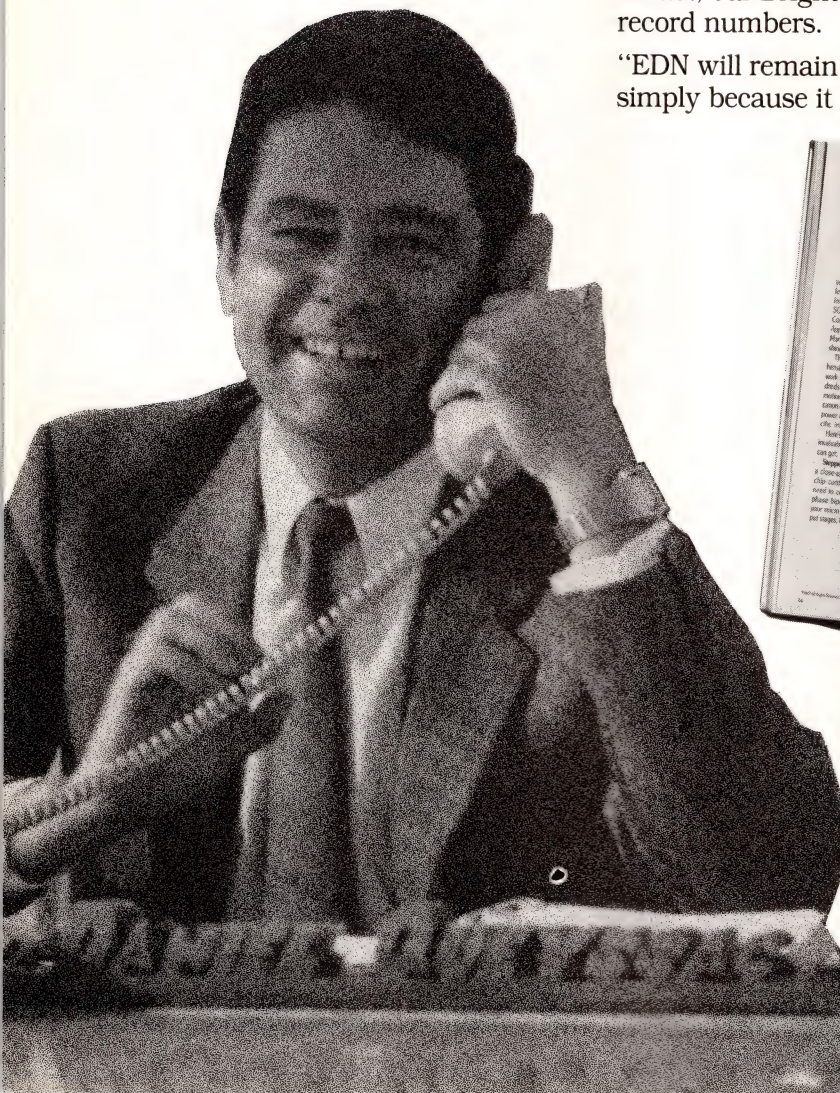
Daniel Queyssac
President
SGS Semiconductor Corporation

As president of SGS Semiconductor Corporation, Daniel Queyssac set a goal of establishing SGS as a leader in power MOS and an innovator in smart power devices. The Brighter Power campaign was created to help get the job done.

To insure that the right audience — design engineers — would get the message, SGS needed the right vehicle. For Queyssac, EDN was the logical choice. "It had performed very well for SGS in the past," says Queyssac, "so, naturally, we expected good results."

"EDN's pulling power exceeded our expectations. In fact, our Brighter Power ads drew inquiries in record numbers."

"EDN will remain at the top of the SGS media list simply because it works."



Advertising in EDN magazine works for
SGS Corporation. It can work for you.

EDN

Where Advertising Works

Mid-sized LCD controller eases window-display development

The software challenge of designing adequate interfaces between complex instruments and their users is becoming increasingly difficult to meet. Many large instruments are using CRTs and keyboards for this interface, but on smaller, (usually portable) instruments, LCD panels are showing up everywhere. The CY325 LCD-window controller eliminates most of the time spent on interface development. This device provides a high-level interface to many LCD panels that have as many as 240×64 pixels (8 rows × 40 characters).

When using LCDs with an instrument, windows can greatly simplify the operation of the product. They can display soft-key status, pull-down menus, pop-up error messages, and many other sophisticated features. However the software tasks of monitoring and controlling windows is not a trivial task. The largest portion of time spent in interfacing to these LCDs involves the making of the software driver that controls the LCD itself—and the CY325 controller facilitates this task.

Generally, the LCD panel has a low-level controller on its pc board that takes parallel information and affects pixels on the screen. Instead of having to send low-level pixel-oriented commands, the CY325 allows you to issue ASCII commands to create windows, erase windows, and draw bar graphs and logic waveforms. For graphics displays, this controller maps the image into a simple coordinate system within the selected window. You can display graphics and text in different planes within the same window.

The controller can communicate with your system via either a serial

or parallel interface, or both. Because of this flexibility, you can design complex distributed systems (the company's CY233 Local Intelligent Network Controller is particularly helpful in such applications).

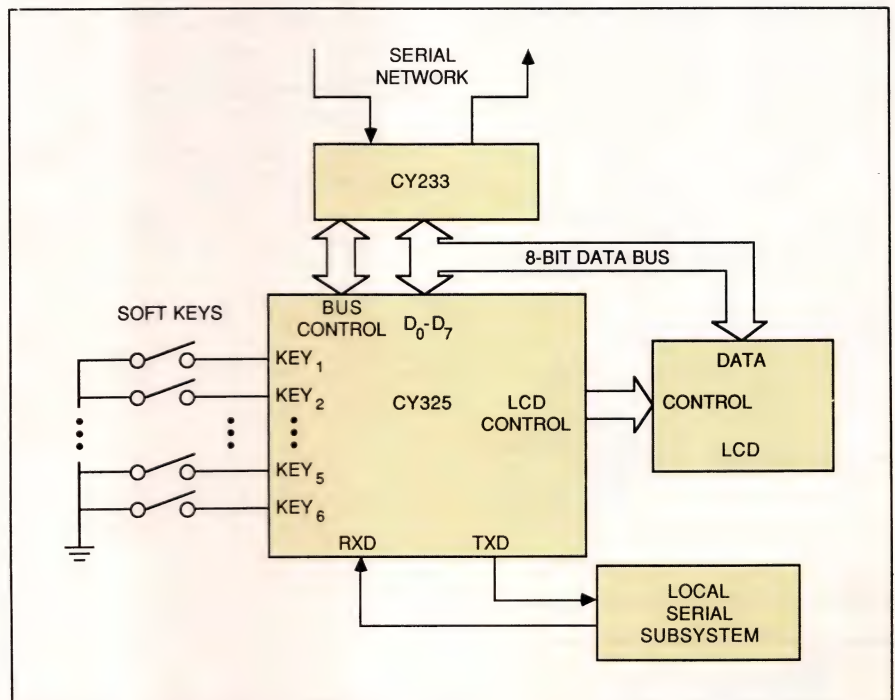
The CY325 operates in two modes, command and display, and you can shift between them by issuing a one-stroke ASCII command. In the display mode, the device places the characters received on the screen at the cursor position. You can also clear a window, swap windows, and do a few other housekeeping operations. The display mode is the default mode at power up.

The command mode puts you directly in touch with the power of the controller. In this mode, you select a command by sending a character

followed by the appropriate parameter values.

You can make a box of any size you wish and control its operation yourself, or you can just use one of the 255 available windows. Using the predefined windows greatly simplifies the basic operation. In the latter case, you can even swap windows and keep all of the last window's control data on a stack. In addition, after finishing with a new window, you can swap back to the last window and pick up where you left off.

The command list includes various simply executed operations, such as histogram generation and logic and waveform display. To generate a histogram, for example, you use the command "Hn, y1, y2, ... yn" and follow it with a carriage return. This command automatical-



The ability to use both the serial and parallel interfaces allows the CY325 LED-window controller to work in conjunction with the CY233 network controller in distributed control applications.

NEW! SWITCHMODE POWER SUPPLIES FROM STOCK

- 2 to 48 VDC Outputs
- Automatic Current Sharing On All Outputs
- N+1 Capabilities



MULTIPLE OUTPUT



- 350 to 1500 Watts
- 3 to 15 Outputs

SINGLE OUTPUT



- 400 to 3000 Watts in 5" x 8" Standard Package
- 155,000 Hrs. Demonstrated MTBF

Hot Plug-In FAULT TOLERANT (N+1) POWER SYSTEMS



- Two to Six Supplies
- Expandable, 300 to 1800 Watts
- Internal Isolation Diodes (Option)

Powertec

A Bonar Power Supplies Company

20550 Nordhoff Street Chatsworth, CA 91311
(818) 882-0004 • FAX (818) 998-4225

CIRCLE NO 9

UPDATE

ly makes a histogram with "n" elements whose values are "y1" through "yn". The histogram can be either horizontal or vertical.

Another headache you can avoid using this controller arises from the difficulty involved in creating quick responses to soft keys. When the operator presses a soft key, the instrument should usually give instant feedback to the user. It's important that the first key pressed has been received and acknowledged and also that any other keys are not accepted until the first one is acknowledged. Otherwise, the user might, in confusion, press the key repetitively and thus make the instrument unusable.

The CY325 has six soft-key inputs, which it constantly scans. The switch connected to these inputs is a momentarily closed mechanism. If you want hardware feedback, the switch should have an LED in parallel. When the user presses a key, the LED lights up and the CY325 accepts the key press. Immediately, the key input is reconfigured to be an output, and the line is kept low. This action causes the LED to remain on until the system acknowledges the key press. The CY325 is available in a 40-pin DIP and costs \$20 (1000).—*David Shear*

*Cybernetic Micro Systems Inc,
Box 3000, San Gregorio, CA 94074.
Phone (415) 726-3000.*

Circle No 702

WORLD-CLASS IC PRODUCTS

SPOTLIGHT #34
IN A SERIES



At Silicon Systems, here are the product lines we have developed in response to your market needs.

MICROPERIPHERAL IC's: We offer more than 50 ASIC chips serving the mass storage market. It includes the industry's most comprehensive line of read/write amplifier IC's for disk drives as well as complete chip sets covering such other disk drive electronic functions as pulse detection; data recovery; head positioning; spindle motor control; and buffer, storage, and interface control. We also offer circuits for optical, floppy, and tape drives; and we are continuously expanding the line.

TELECOMMUNICATIONS IC's: For U.S. or world-wide telecom systems operating at 300 to 2400 BPS data transfer speeds, Silicon Systems can provide the industry's most advanced family of software/hardware compatible, single-chip modem IC's available. These pin-out and register-compatible K-Series chips allow for easy product upgrading over the entire Bell and CCITT ranges, and Silicon Systems also offers more than a score of other telecom IC's for a variety of applications in tone signaling, telephony, and digital communications.

CUSTOM / SEMICUSTOM IC's: And beyond its lines of standard ASIC's, Silicon Systems continues to offer—as it has since its inception—its innovative bipolar and CMOS design and manufacturing capabilities as a unique resource for complex custom/semicustom products.

For more information, contact: **Silicon Systems**, 14351 Myford Road, Tustin, CA 92680. Phone: (714) 731-7110, Ext. 575.

silicon systems
INNOVATORS IN INTEGRATION

CIRCLE NO 10

IF YOU'RE DESIGNING DISK DRIVES AND HAVE ONLY USED OUR READ/WRITE CIRCUITS— THIS CHART IS FOR YOU.

Our Extended Family

If you're designing disk drives, you're probably already familiar with Silicon Systems. Chances are good that you are presently using one or more of Silicon Systems' Read/Write amplifier IC's in your HDD designs. But maybe you don't know that we also offer the industry's most extensive line of mass storage ASIC's.

The adjacent chart illustrates that Silicon Systems can also provide more than a score of circuits for pulse detection, data recovery, head positioning, spindle motor control, and controller electronics. And the list continues to grow.

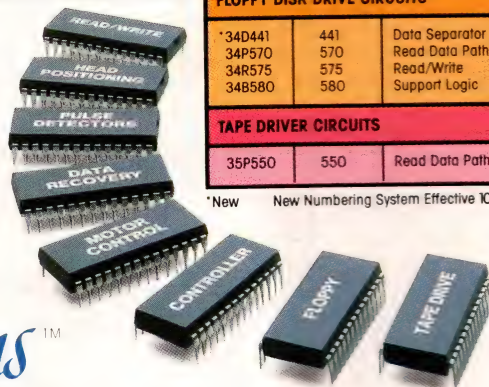
The Mix-and-Match Design Approach

With Silicon Systems growing families of IC's for all the electronic functions in hard disk drives, many leading HDD designers are finding they can now easily mix-and-match SSI products to implement their specific design features. This powerful design approach allows them to reduce board area, eliminate external passives, and lower costs by simplifying their designs.

Call Now!
(714) 731-7110, Ext. 575

For more information,
send for our Disk Drive
mailers. **Silicon Systems**,
14351 Myford Road,
Tustin, CA 92680.

silicon systems™
INNOVATORS IN INTEGRATION



MICROPERIPHERAL IC SELECTION CHART

SSI Device Numbers		Head Type	# of Channels	Max Input Noise nV/√Hz	Max Input Capacitance (pF)	Read Gain (typ)	Write Current Range (mA)	Power Supplies	Read/Write Data Port(s)
New	Old								
HDD READ/WRITE AMPLIFIERS									
32R104B	104	Ferrite	4	2.4	23	35	15 to 45	+6V, -4V	Differential, Bi-directional
32R104BLN	104L	Ferrite	4	1.7	23	35	15 to 45	+6V, -4V	Differential, Bi-directional
32R114	114	Thin Film	4	1.1	65	123	55 to 110	±5V	Differential/Differential
32R115	115	Ferrite	2, 4, 5	1.8	20	40	30 to 50	±5V	Differential, Bi-directional
32R117	117	Ferrite	2, 4, 6	2.1	23	100	10 to 50	+5V, +12V	Differential/TTL
32R117A	117A	Ferrite	2, 4, 6	1.7	20	100	10 to 50	+5V, +12V	Differential/TTL
32R188	188	Ferrite	4	2.4	18	43	35 to 70	+6V, -5V	Differential, Bi-directional
32R501	501	Ferrite	4, 6, 8	1.5	23	100	10 to 50	+5V, +12V	Differential/TTL
*32R510A	510A	Ferrite	2, 4, 6	1.5	20	100	10 to 40	+5V, +12V	Differential/TTL
*32R511	511	Ferrite	4, 6, 8	1.5	20	100	10 to 40	+5V, +12V	Differential/TTL
*32R512	512	Thin Film	8	0.9	32	150	10 to 40	+5V, +12V	Differential/TTL
*32R514	514	Ferrite	2, 4, 6	1.5	20	150	10 to 40	+5V, +12V	Differential/TTL
32R520	520	Thin Film	4	0.9	65	123	30 to 75	±5V	Differential/Differential
32R521	521	Thin Film	6	0.9	65	100	20 to 70	+5V, +12V	Differential/TTL
*32R522	522	Thin Film	4, 6	1.0	32	100	6 to 35	+5V, +12V	Differential/TTL
HDD PULSE DETECTION									
32P540	540	Read Data Processor				Time Domain Filter			
32P541	541	Read Data Processor				AGC, Amplitude & Time Pulse Qualification, RLL Compatible			
HDD DATA RECOVERY									
32D531	531	Data Synchronizer				Data Synchronizer/Write Precompensation			
*32D532	532	Data Separator				Data Synchronizer/2, 7 RLL ENDEC			
*32D533	533	Data Synchronizer				Data Synchronizer/Write Precompensation			
*32D534	534	Data Separator				Data Synchronizer/MFM ENDEC/Write Precompensation			
*32D535	535	Data Separator				Data Synchronizer/2, 7 RLL ENDEC/Write Precompensation			
HDD HEAD POSITIONING									
32H101A	101A	Preamplifier-Ferrite Head				AV = 93, BW = 10MHz, $e_n = 7.0nV/\sqrt{Hz}$			
32H116	116	Preamplifier-Thin Film Head				AV = 250, BW = 20MHz, $e_n = 0.94nV/\sqrt{Hz}$			
*32H567	567	Servo Demodulator				DI-bit Quadrature Servo Pattern: PLL Synchronization			
*32H568	568	Servo Controller				Track & Seek Mode Operation; Microprocessor Interface			
*32H569	569	Servo Motor Driver				Head Parking, Spindle Motor Braking			
HDD SPINDLE MOTOR CONTROL									
32M590	590	2-Phase Motor Speed Control				±0.035% Speed Accuracy; Unipolar Operation			
32M591	591	3-Phase Motor Speed Control				±0.05% Speed Accuracy; Unipolar Operation			
*32M593	593	3-Phase Motor Speed Control				±0.037% Speed Accuracy; Bipolar Operation			
HDD CONTROLLER/INTERFACE									
*32B450A	450A	SCSI Controller				Async transfer to 2MBPS; Initiate/Target Modes; Internal Drivers; CMOS			
*32C452	452	Storage Controller				20Mbits/sec; CMOS; Programmable; AIC-010 Compatible			
*32C453	453	Buffer Controller				Non-mux addressing to 16K; CMOS; AIC-300 Compatible			
32B545	545	Support Logic				Includes ST506 Bus Drivers/Receivers			
FLOPPY DISK DRIVE CIRCUITS									
*34D441	441	Data Separator				High Performance Analog Data Separator, NEC 765 Compatible			
34P570	570	Read Data Path				2 Channel Read/Write With Read Data Path			
34R575	575	Read/Write				2, 4 Channel Read/Write Circuit			
34B580	580	Support Logic				Port Expander, Includes SA400 Interface Drivers/Receivers			
TAPE DRIVER CIRCUITS									
35P550	550	Read Data Path				4 Channel Read/Write With Read Data Path			

*New New Numbering System Effective 10/1/87

"Where we design to your applications."

200M-sample/sec 8-bit A/D converter provides 250-MHz bandwidth

Assessing a converter's speed involves more than just looking at the conversion rate. You should consider both the input bandwidth and the input capacitance as well. The AD770 is an 8-bit 200M-sample/sec ADC with a full-power bandwidth of 250 MHz and an input capacitance of 19 pF. The device has an S/N ratio of 45 dB at 10 MHz and 30 dB at 100 MHz. This high-frequency S/N ratio falls short of the 48-dB S/N ratio considered ideal for an 8-bit A/D converter, but it's better than the rates offered by any competing converters.

Until now, all of the available high-speed (greater than 100M samples/sec) ADCs had a bandwidth that was less than the sample rate. By providing a bandwidth greater than its sample rate, the AD770 offers some advantages that may not be obvious at first glance.

A high-speed front end is a plus in an ADC for many reasons. The 250-

MHz bandwidth size in itself is important. The signal is attenuated 3 dB at this frequency and has therefore lost 50% of its power. If you are interested in the amplitude of all frequencies in the passband, you need a flat response. Having a bandwidth of 250 MHz provides a flat response to the Nyquist frequency.

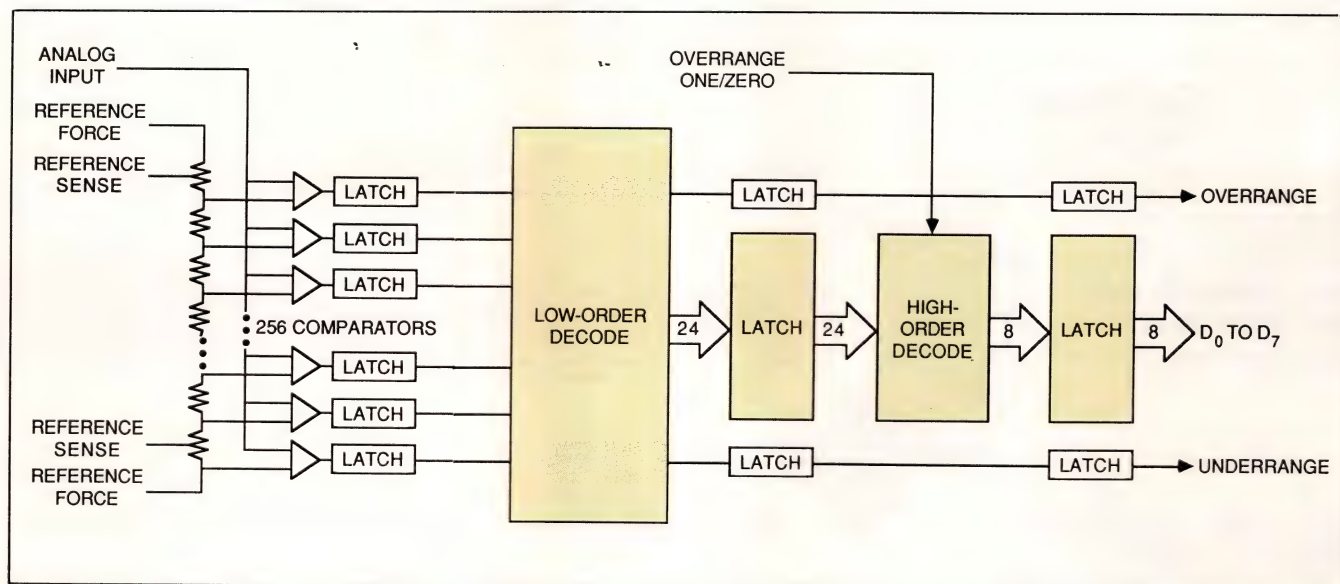
Another benefit of a wide bandwidth is that the input voltage can change drastically, but you don't have to wait for the front end to settle in order to proceed. Dramatic voltage changes can occur when using a multiplexed input to the ADC; the voltage can change the full voltage range between channels. Naturally, the faster the input is and the less time you must wait for the input to settle, the faster your system can acquire data.

When acquiring repetitive signals, a converter also exploits a wide bandwidth. The standard technique for acquiring repetitive

signals whose frequencies are greater than the sample rate is to sample one point on the waveform and then sample another on the next cycle, yet another on the next cycle, and so on. Eventually, the converter acquires all of the samples necessary to represent the waveform. With a wide input bandwidth, you can reproduce the input signal with less distortion.

When there are no errors, the comparators with references below the input voltage are all 1s and all those above are 0s. When noise or offsets cause a comparator that is above the input to erroneously go high (or one below to go low), the decoder logic gets confused, resulting in a large error in the output. The error detection and correction circuitry in the AD770 detects these mistakes (called sparkle codes) and modifies the input to the decoder logic to eliminate these errors.

An evaluation board is available



The AD770 8-bit ADC uses three levels of pipelining to maintain a 200 MHz conversion rate. Overrange and underrange outputs indicate any out-of-range condition and can be ORed for a single out-of-range indication.

UPDATE

for the AD770. The AD EB770 includes a socket for an AD770, an input-signal buffer, and a trimmable reference generator. On the output side, the digital data is latched and buffered and available along with the output clock. The board also includes hardware to scale the output clock by factors of 2 through 16, so you can interface slower logic analyzers to the output. An onboard DAC reconstructs the output.

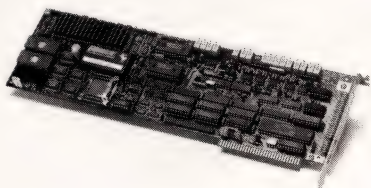
The device can accept bipolar inputs, consumes 2100 mW, and requires power supplies of +5 and -5.2V. The AD770 is packaged in a 40-pin ceramic DIP and costs \$175 (100). The AD EB770 evaluation board without the ADC costs \$635.

—David Shear

Analog Devices, Box 9106, Norwood, MA 02062. Phone (617) 329-4700. TLX 924491.

Circle No 703

DATA ACQUISITION PROCESSOR™



ONBOARD INTELLIGENCE FOR IBM PC/XT/AT

- analog and digital I/O to 150,000 samples/second
- 80186 coprocessor—realtime processing
- onboard software, including FFT
- run applications without programming
- direct access to Lotus 1-2-3
- full documentation with sample applications and tutorial - \$20
- digital I/O from \$995
- analog I/O from \$1595

**MICROSTAR
LABORATORIES**

(206) 881-4286
2863 152nd Ave N.E.
Redmond, WA 98052
TLX 5106013473

CIRCLE NO 13

EDN May 12, 1988

Rechargeable Lithium for Memory Back-up!

Moli Energy offers two standard MOLICEL® rechargeable lithium battery packs specially designed for memory back-up applications in computers, process control equipment, and portable devices. The packs use MOLICEL® "AA" size cells and can be constant voltage charged from any DC power source.

Reliable long life memory protection:

- Longer use than lithium primaries or alkalines—hundreds of cycles
- No memory effect problems
- Simple and inexpensive charge circuitry
- Low self discharge
- No voltage delay
- DOT and UL recognition



MOLI Energy Limited
3958 Myrtle Street
Burnaby, B.C.
Canada V5C 4G2

1-800-663-MOLI

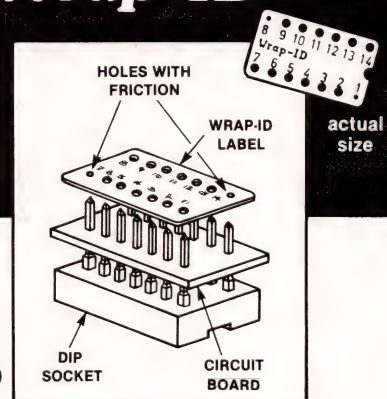
CIRCLE NO 11

Use amlan Wrap-ID markers to identify wire wrap pins.

- Speed wiring
- Reduce errors
- Simplify troubleshooting

White plastic markers (.019" thick) are friction fit over wire wrap pins of standard DIP sockets. Every pin is permanently numbered on wiring side, with clear space in center for your socket number, etc. All standard sizes from 8 to 96 pins, each with its own distinctive marking color for added ease of identification.

Call or write for data sheet, price list, and free samples.



amlan inc.

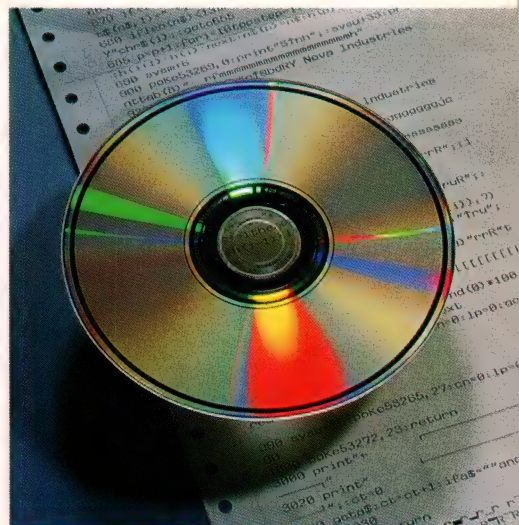
97 Thornwood Road, Stamford, CT 06903
(203) 322-1913 Telex: 643647

CIRCLE NO 12



**Easy-flowing
plastics with high
moulding
accuracy?**

**Take a tip
from PDO:
Talk to
Bayer!**



Example: Data storage disc made of Makrolon CD 2000

If you're looking for the right material, why not do as the Design Department of Philips-Dupont-Optical did. Talk to Bayer!

For non-erasable optical data storage discs PDO uses the high-performance engineering plastic Makrolon CD 2000. An extremely light, easy-flowing plastic which will produce data storage discs with a very high accuracy of reproduction and very low double refraction.

Bayer offers one of the world's biggest ranges of high-performance engineering plastics:

®Apec (PAR), ®Bayblend (PC + ABS),
®Bayfol (PC blend film), ®Baygal/
Baymidur (PUR cast resin), ®Desmopan
(TPUR), ®Durethan (PA 6/PA 66),
®Leguval (UP), ®Lekutherm (EP),
®Makroblend (PC blends), ®Makrofol
(PC film), ®Makrolon (PC), ®Novodur
(ABS), ®Petlon (PET), ®Pocan (PBT),
®Tedur (PPS).

Whether it's flowability, the highest accuracy of reproduction or other properties you need:

Talk to Bayer – so that material problems become material solutions.

For more information write to:
Bayer AG, AV-Informationsvermittlung
Postfach 80 0149, D-5000 Köln 80

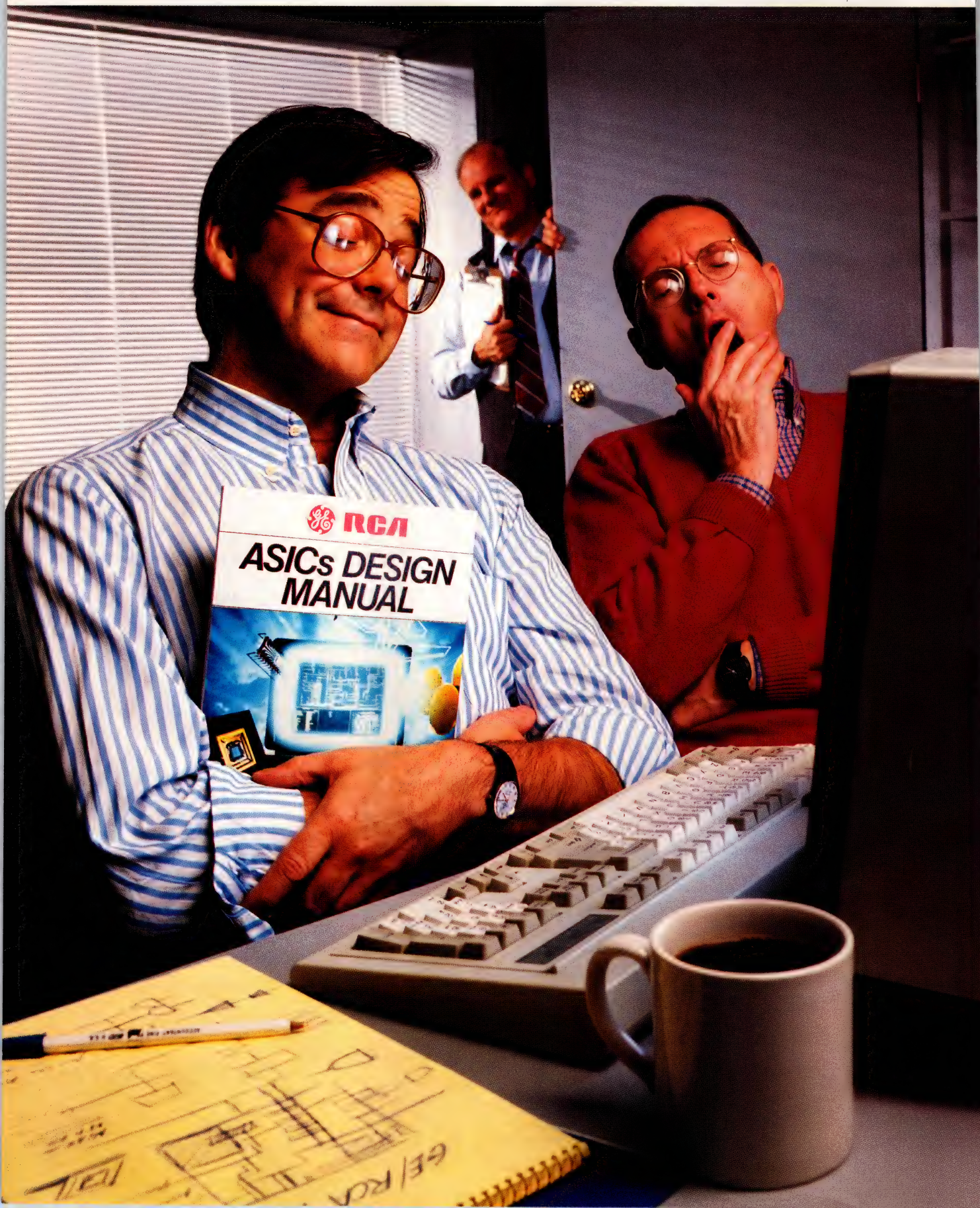
CIRCLE NO 108

Plastics Business Group

Bayer



Our ASICs



are boring.

They're easy to design. They're ready on time.
And first-time success is virtually 100%.

You've heard all about the excitement of ASICs.

They improve performance, lower costs and make many new designs possible.

But, unfortunately, you've probably also heard about one big potential problem: while many ASICs pass the tests specified by the designer, they don't always work in the real world. And that causes excitement you can do without.

How to get first-time success.

It starts with our Design Simulation Software. It's been rated the best in the industry by the people who should know—designers who have used it. Within three days, you can be up to speed, working at any of the major workstations in the industry, creating and revising your ASIC with ease.

The standard cell advantage.

You'll really appreciate the power of our standard cells, which allow you to integrate a whole system, including macros, memories, logic and peripherals, onto a single chip.

We have cells with effective gate length as small as 1.5μ ($.9\mu$ coming soon). And double-level metal for higher-density chips that can handle higher clock speeds.

You can choose from a wide range of Supercells, including the leading-edge RS20C51 core micro, RAMs, analog functions, bit-slice processors, HC/HCT logic, Advanced CMOS Logic, and high-voltage cells.

If they aren't enough, we can even generate

Supercells to your specs.

And we're also in the forefront of silicon compiler technology. So we can offer you the ability to create designs that are heavily BUS-structured, with your ROMs, RAMs, PLAs and ALUs compiled right into the design.

We also bring you the resources of some very powerful partners, thanks to our alternate-source agreements with VLSI on standard cells; WSI on macrocells and EPROMs; and a joint-development agreement with Siemens and Toshiba on the Advancell® library of small-geometry cells.

Gate arrays, too.

If gate arrays are better for your design, you'll be able to choose from our full line up to 50,000 gates, with effective gate length as small as 1.2μ and sub 1 ns gate delays.

These gate arrays use "continuous gate" technology for up to 75% utilization. They are an alternate source to VLSI Technology arrays.

We also alternate source the LSI Logic 5000 series.

And we have a unique capability in high-rel ASICs, including SOS. Our outstanding production facilities here in the U.S. produce high-quality ASICs in high volume at very low costs.

It almost sounds exciting for something so boring, doesn't it?

For more information, call toll-free today 800-443-7364, ext. 25. Or contact your local GE Solid State sales office or distributor.

In Europe, call: Brussels, (02) 246-21-11; Paris, (1) 39-46-57-99; London, (276) 68-59-11; Milano, (2) 82-291; Munich, (089) 63813-0; Stockholm (08) 793-9500.



GE Solid State

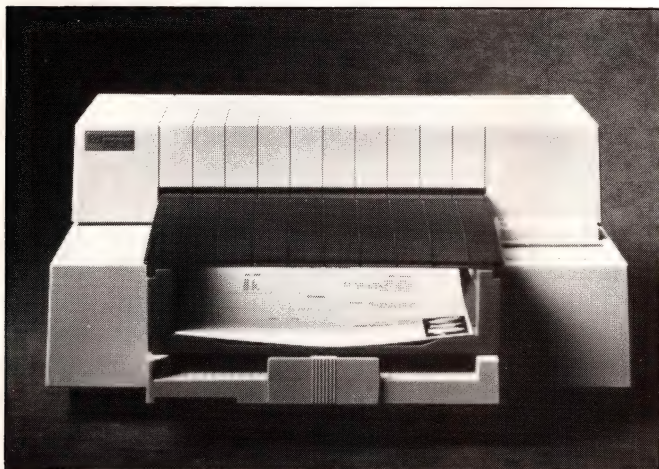
GE/RCA/Intersil Semiconductors

Three great brands. One leading-edge company.

*Trademark of General Electric Company, U.S.A.

READERS' CHOICE

Of all the new products covered in EDN's **February 18, 1988**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, use EDN's Express Request service, or refer to the indicated pages in our **February 18, 1988**, issue.

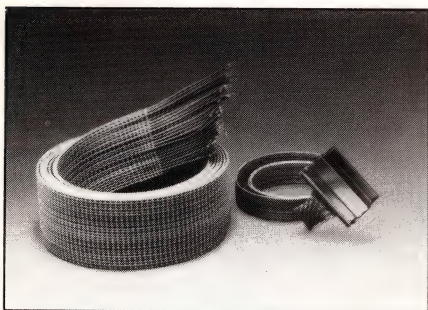


◀ PRINTER

The DeskJet is a personal printer with laser-quality output. It employs inkjet technology, but prints high-resolution text and full-page graphics at 300 dots/in. (pg 290).

Hewlett-Packard Co.

Circle No 603



◀ COAXIAL CABLE

This subminiature ribbon coaxial cable is highly flexible. You can fold it upon itself, bundle it in rectangular or round sections, or group it with other cable for routing (pg 265).

Woven Electronics.

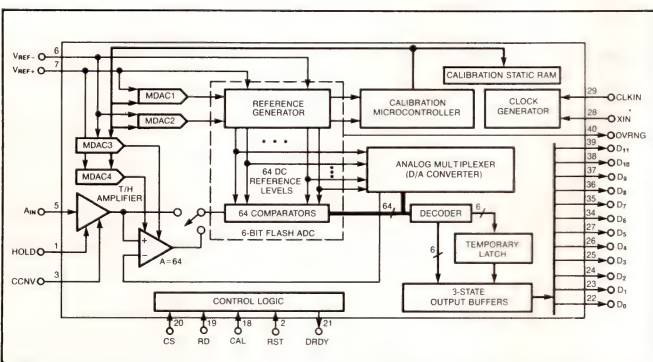
Circle No 602

PLD PROGRAMMER

The Avpal PLD programmer accepts JEDEC files created by CUPL and other PLD programming languages (pg 314).

Avocet Systems Inc.

Circle No 605

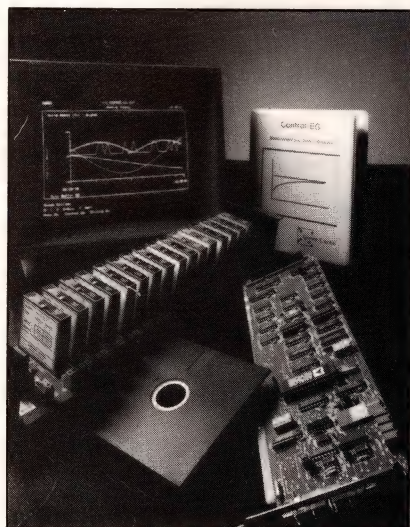


◀ A/D CONVERTER

The CSZ5412-JC2 is a monolithic A/D converter that delivers 1-MHz, 12-bit performance at a low cost (pg 128).

Crystal Semiconductor Corp.

Circle No 601



▲ CONTROL SOFTWARE

Control EG is a menu-driven, data-acquisition, process-control software package that can monitor as many as 128 analog inputs and control as many as 32 analog outputs (pg 299).

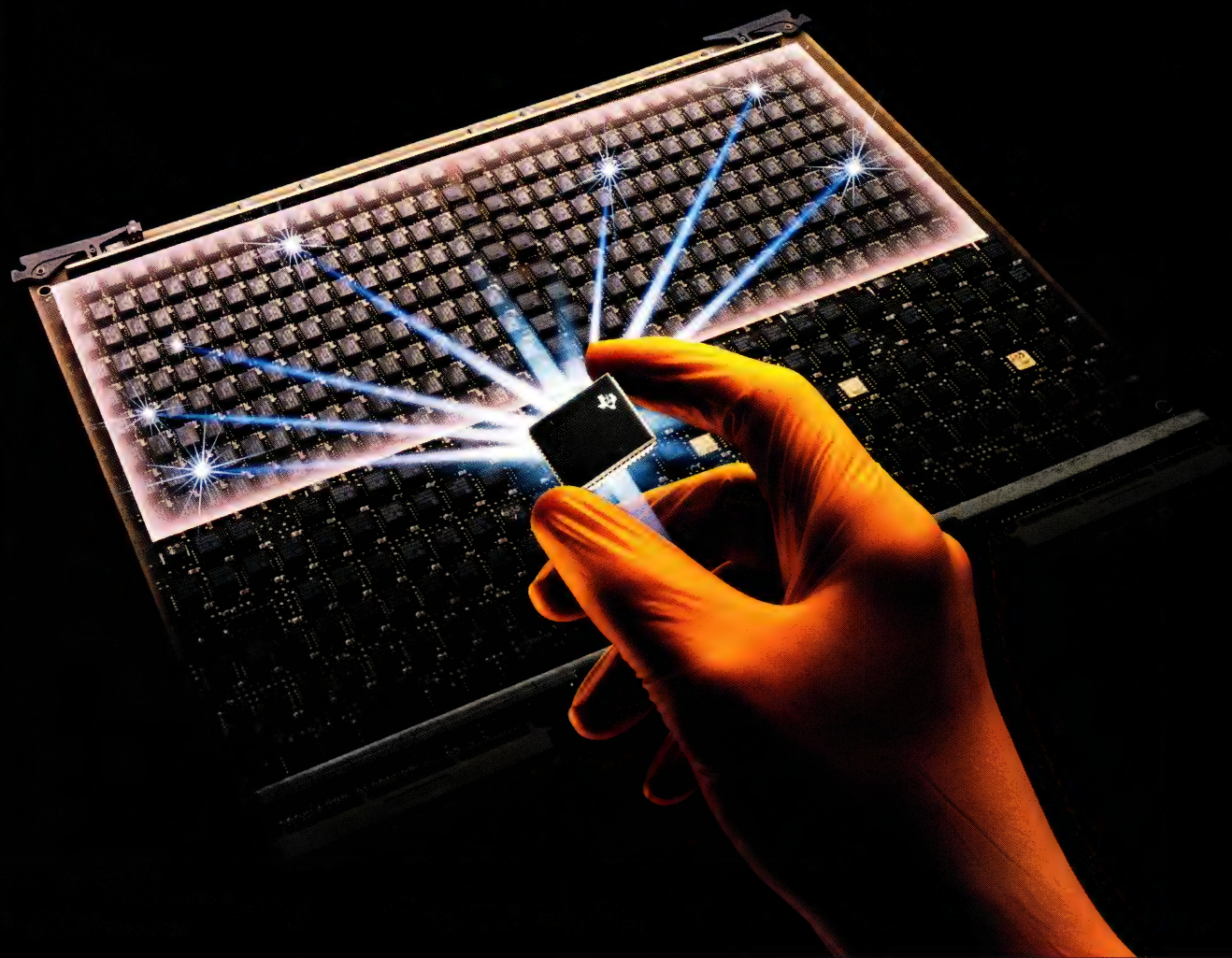
Analog Devices.

Circle No 604

TEXAS INSTRUMENTS REPORTS ON
**MEMORY
MANAGEMENT**

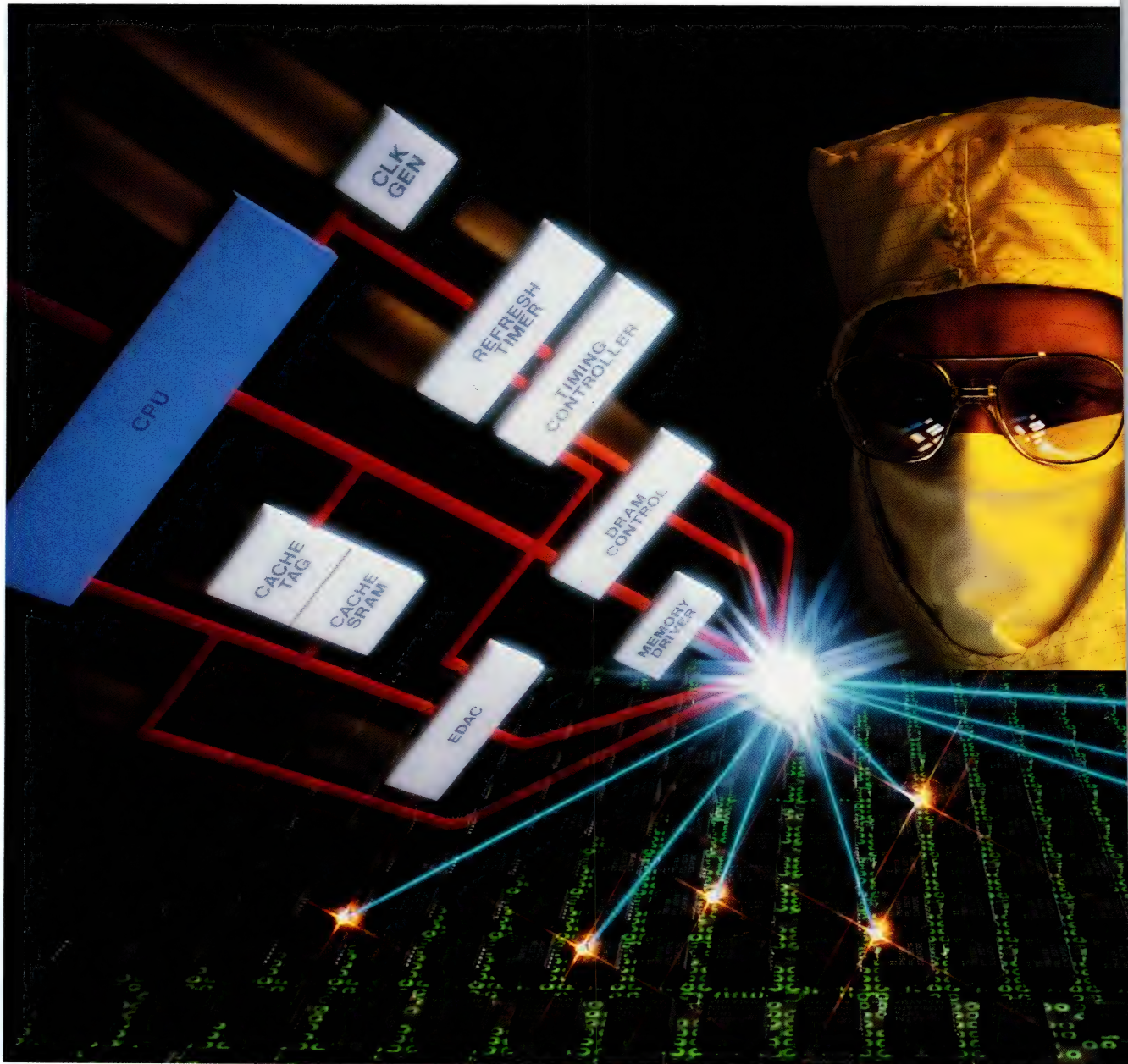
IN THE ERA OF

MegaChip [□]
TECHNOLOGIES



Memory management in the Era of MegaChip Technologies:

Memory-management ICs from TI you bring memory arrays up to



Memory systems are a prime area for significant improvements in overall system throughput. Read how TI's memory-management ICs can get you in and out of memory faster no matter which processor you choose.

You can now solve a problem whose solution has eluded design engineers for years: How to catch memory speeds up to CPU speeds. The solution lies with TI's advanced memory-management circuits, and you can use them with whichever processor best suits your application.

Texas Instruments can help processor speeds.

TI's comprehensive Memory Management Design Kit (see page 4).

TI addresses your major memory-design concerns

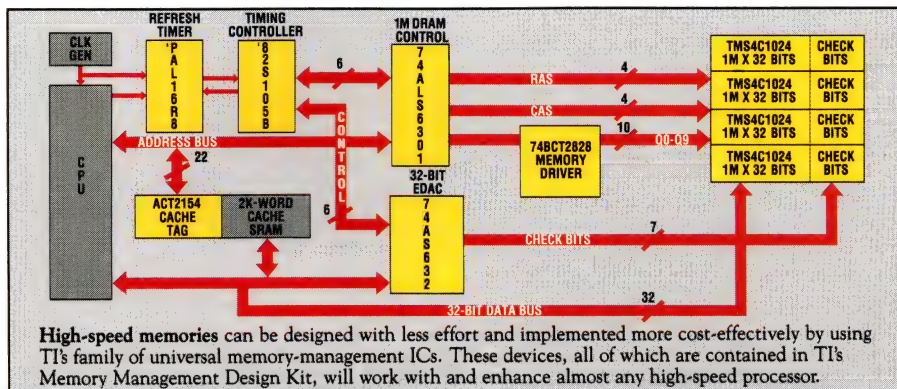
To immediately improve memory-access time, use both main and cache memories, as shown in the block diagram. This approach can produce up to a 3X increase in system performance.

Frequently accessed data and instructions are stored in a few high-speed static random-access memories and "tagged" by a TI industry-standard cache controller (SN74ACT2151/4). These 2Kx8 CMOS controllers are the fastest available and can support deep cache architectures of 16K or even 32K.

TI's MegaChip Technologies

Our emphasis on volume manufacturing of high-density circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers. These are our MegaChip™ Technologies. They are the means by which we can help you and your company get to market faster with better, more competitive products.

tions on chip to improve flexibility and speed and to allow for custom timing routines. This controller supports nibble- and page-mode access and scrubbing-mode refresh to increase memory output.



This scheme is cost-effective because slower, less expensive dynamic random-access memories (DRAMs) can be used for main memory.

When you must assure system integrity, use of an error-detection-and-correction (EDAC) circuit can improve system reliability 500-fold. Since this approach is necessary with memory arrays larger than half a million bits, TI offers its leadership 32-bit EDAC.

The SN74AS632 detects dual-bit errors and detects and corrects single-bit errors while avoiding processor wait states. And at 25 ns for error detection, it meets your high-performance needs.

Interfacing between processor and main memory gets tougher as speeds increase. But TI has the SN74ALS6301 DRAM timing controller. It can handle any DRAM up to 1 Mbit and incorporates only the essential func-

Soon to come: An ASIC (application-specific integrated circuit) solution.

Reducing over/undershoot is accomplished by TI's 2000 Series buffers and drivers — 25-ohm series-damping resistors on the output prevent false reads at DRAM input. For example, the SN74BCT2828 driver can reduce undershoot by 40% compared to traditional approaches. TI's 2000 Series has a high-drive current suitable for VME and MULTIBUS® II bus structures.

You can use any or all of TI's memory-management ICs to obtain the superior performance that marks a market winner. And there's no design rule that says your memory-management chips and your CPU have to come from the same supplier.

► Turn page for more information.



The tools you need to design a high-performance memory-management system are between these covers:

At \$149, the value of TI's Design Kit far outweighs its cost. In one compact file, we've included just about everything you'll need to bring your memory array up to speed. Everything, that is, except your imagination in creating your own unique product differentiators. Here's what you get:

- All necessary high-performance ICs, including
 - SN74ACT2154 2K×8 Cache Address Comparator
 - SN74AS632 32-bit EDAC
 - SN74ALS6301 16K to 1 Mbit DRAM Controller
 - SN74BCT2828 10-bit Buffer/Driver with series-damping resistor
 - TIBPAL16R8-10 and TIB82S105B High-speed Programmable-logic Devices for user-defined timing control
 - TMS4464 256K DRAM
- *Memory Management Applications Handbook* containing applications reports and briefs that supply valuable insights into memory-management system design.
- Data sheets on TI circuits designed for efficient memory management.
- Memory-management-product software graphic-symbol libraries and supporting documentation for use with Futurenet™ or Mentor Graphics™ CAE systems.

For more information on TI's Memory Management Design Kit, call 1-800-232-3200, ext. 3203, or contact your nearest TI field sales office or authorized distributor.



Texas Instruments Incorporated

SDV063ED800C

P.O. Box 809066
Dallas, Texas 75380-9066

YES, please send me more details on TI's universal memory-management ICs.

NAME

TITLE

COMPANY

ADDRESS

CITY

STATE

ZIP

AREA CODE

TELEPHONE

EXT.

[™] MegaChip is a trademark of Texas Instruments Incorporated.
Futurenet is a trademark of Futurenet Corporation.
Mentor Graphics is a trademark of Mentor Graphics Corporation.
® MULTIBUS is a registered trademark of Intel Corporation.

If you think HP board testers aren't affordable, think again.

the never
stop
asking

What if...



If you want a complete board tester that meets your needs at a price you'll like, consider the new HP 3065ST.

It's surprisingly affordable, with many standard features not found on other board testers under \$100,000.

You get multi-user capability without the headaches of foreground/background systems. Automatically generated 6-wire analog measurement. Analog functional testing. A vector application rate of 2.5 MHz. A high-speed digital library with more than 4,500 devices. 81 megabytes of mass storage. And more. *All standard.*

There's also complete software and fixture compatibility across the HP 3065 family. So you can start small and easily expand as you grow.

And like all HP board testers, the HP 3065ST is

available with HP's exclusive 99% Guaranteed Uptime program.*

Call HP today!

Get into affordable board test now. For more information, call 1-800-634-TEST. In Colorado, call collect: 303-669-9325.

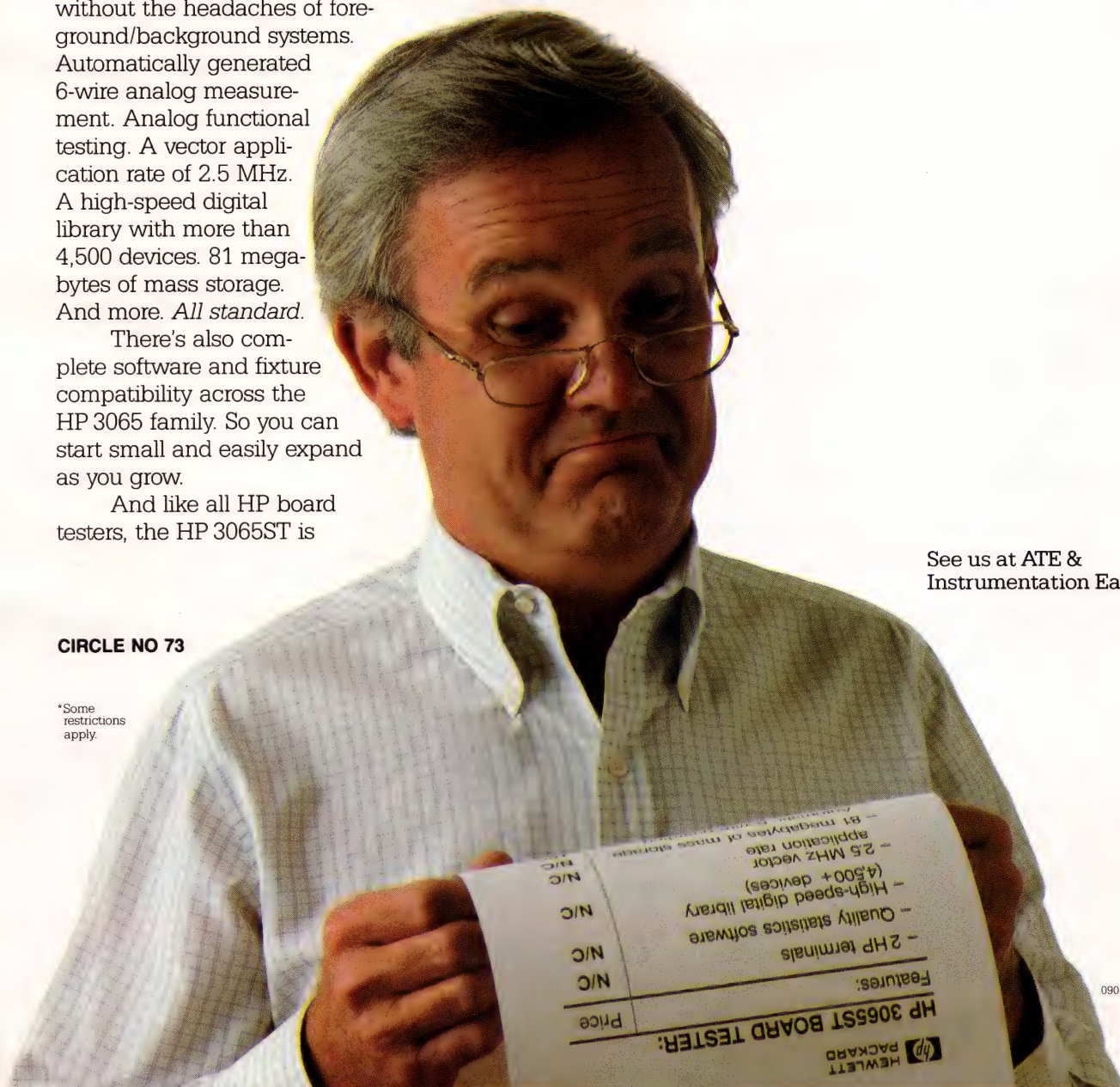


**HEWLETT
PACKARD**

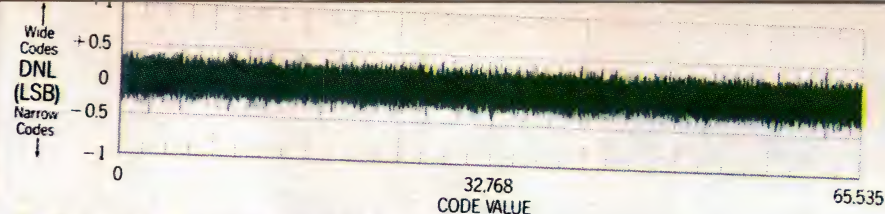
CIRCLE NO 73

*Some restrictions apply.

See us at ATE & Instrumentation East

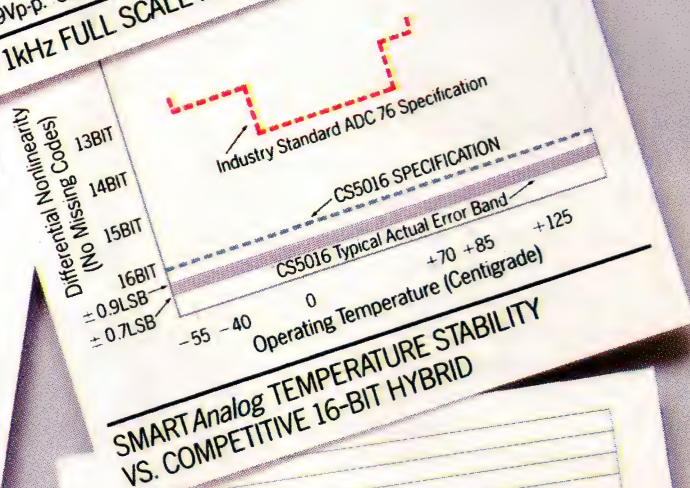
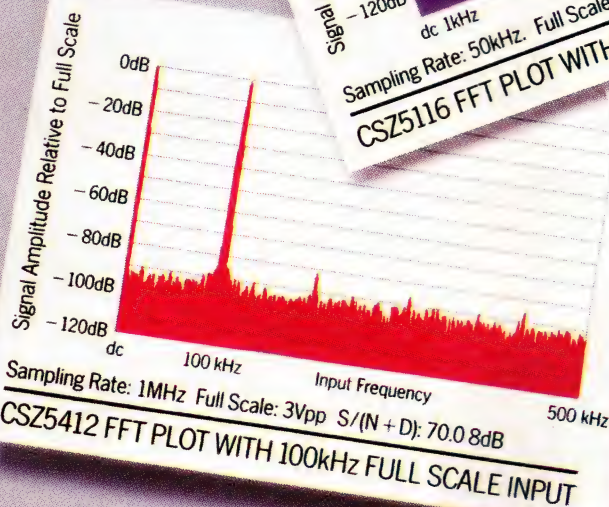
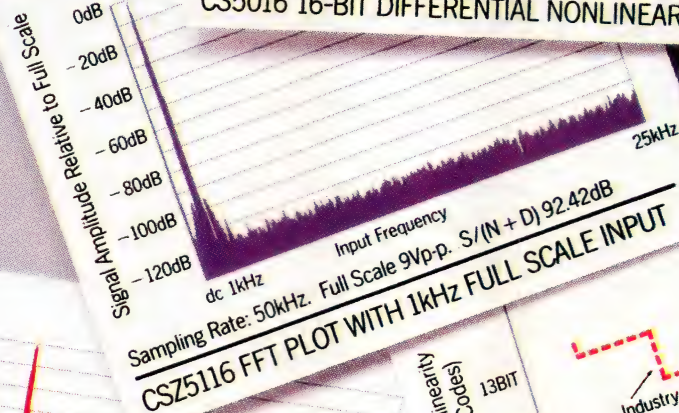


HP 3065ST BOARD TESTER:	
Price	N/C
Features:	N/C
- 2 HP terminals	N/C
- Quality statistics software	N/C
- High-speed digital library (4,500+ devices)	N/C
- 2.5 MHz vector application rate	N/C
- 81 megabytes of mass storage	N/C

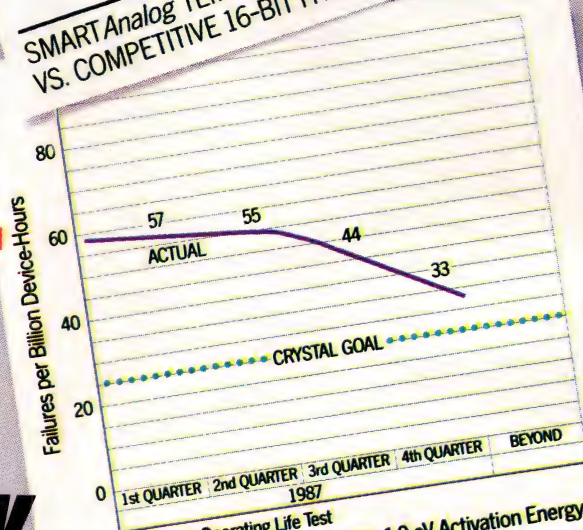


Shows $< \pm 0.7$ LSB code width variation from ideal (definitely no missed codes)

CS5016 16-BIT DIFFERENTIAL NONLINEARITY AT 16 μ SEC CONVERSION TIME



SMART Analog TEMPERATURE STABILITY
VS. COMPETITIVE 16-BIT HYBRID



SMART Analog RELIABILITY

**OUR 12-TO 16-BIT
CMOS A/D
CONVERTERS LOOK
GREAT ON PAPER.**

**AND ARE THE WORLD'S
BEST IN ACTION.**

Anyone can promise the world's best performance from monolithic CMOS A/D converters. Only Crystal can prove it.

Get your hands on the evaluation board of a Crystal SMARTAnalog™ device and you'll believe the breakthrough performance the plots on the opposite page promise.

Dynamic performance really is 92 dB SNR over a 25 kHz bandwidth, or 70 dB over 500 kHz.

Differential Non-Linearity of 16 bits with no missing codes is so outstanding we've published a DNL plot no one else dares to.

Stability over temperature is dramatically better than the competition across the entire military range.

Our reliability far surpasses the alternatives, with less than 33 failures per billion operating hours (FITs).

What the plots don't show, you already know: monolithic A/D converters using CMOS technology mean lower design and assembly costs, higher reliability,

DEVICE	STATIC-TESTED ADCs				DYNAMIC FFT-TESTED ADCs				
	CS5016	CS5014	CS5012	CS7820	CS25412	CS25316	CS25116	CS25114	CS25112
Resolution	16	14	12	8	12	16	16	14	12
Conversion Time (μsec)	16	14	7	1.3	1.25	16	16	14	7
Throughput Speed (kHz)	50	56	100		1000	20	50	56	100
Static Specifications:									
Linearity Error (% FS, max)	+/- .0015	+/- .003	+/- .012	+/- .2	+/- .01				
No Missing Codes (Bits)	16	14	12	8	12	16	16	14	12
Dynamic Specifications:									
THD (%)					.02	.007	.001	.003	.008
S/(N+D) (dB)					70	84	92	83	73
Power Dissipation (mW)	120	120	120	40	700	220	120	120	120
On-Chip Sample and Hold	YES	YES	YES	YES	YES	YES	YES	YES	YES

The proof behind the promise: monolithic CMOS performance that beats even hybrids.

bility, lower power consumption, easier manufacturing and faster deliveries than hybrid or discrete designs can manage.

And our SMARTAnalog devices are the first with self-calibration at any time/temperature. Which ensures accuracy throughout their operating lives, correcting for gain, offset and even linearity errors. Automatically.

If that weren't enough, Crystal's SMARTAnalog line is the first line of 12- to 16-bit A/D converters with the converter, track/hold, digital interface, calibration circuitry and timing all on a single chip. So you can forget designing, building and characterizing discrete

devices while trying to correlate component specifications with system requirements.

Prove to yourself how our revolutionary SMARTAnalog technology makes hybrids a very expensive proposition, indeed. Call 512-445-7222 today for your very own 12-, 14- or 16-bit evaluation board. Or ask for a demonstration at your facility.

Either way, you'll know why seeing a SMARTAnalog converter in action makes our promises on the opposite page seem flat by comparison.

CRYSTAL
SEMICONDUCTOR CORPORATION
P.O. Box 17847, Austin, TX 78760



512-445-7222: CALL TODAY

LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Last month's average (weeks)	Average (weeks)
TRANSFORMERS								
Toroidal	0	25	50	13	12	0	9.7	7.3
Pot-Core	0	20	40	40	0	0	10.0	7.8
Laminate (power)	10	30	20	30	10	0	9.6	8.3
CONNECTORS								
Military panel	0	22	45	22	11	0	10.4	10.8
Flat/Cable	13	47	33	7	0	0	4.7	5.6
Multi-pin circular	0	25	33	25	17	0	11.6	9.4
PC (2-piece)	8	25	50	17	0	0	7.2	7.4
RF/Coaxial	13	47	27	13	0	0	5.2	5.3
Socket	12	63	19	6	0	0	3.7	4.7
Terminal blocks	19	31	37	13	0	0	5.7	5.4
Edge card	12	29	53	6	0	0	5.8	5.7
D-Subminiature	13	50	31	6	0	0	4.4	5.1
Rack & panel	10	40	30	20	0	0	3.2	6.4
Power	20	30	40	10	0	0	5.4	5.5
PRINTED CIRCUIT BOARDS								
Single-sided	0	71	29	0	0	0	3.7	5.4
Double-sided	0	25	75	0	0	0	6.5	5.8
Multi-layer	0	20	67	13	0	0	7.8	7.5
Prototype	6	81	13	0	0	0	2.7	4.3
RESISTORS								
Carbon film	47	32	16	5	0	0	2.7	4.2
Carbon composition	42	21	26	11	0	0	4.3	4.0
Metal film	30	25	45	0	0	0	4.1	4.4
Metal oxide	18	55	18	9	0	0	4.0	4.6
Wirewound	11	39	28	22	0	0	6.5	8.8
Potentiometers	5	53	32	10	0	0	5.2	6.1
Networks	19	38	24	19	0	0	5.7	6.3
FUSES								
	39	33	28	0	0	0	2.9	4.4
SWITCHES								
Pushbutton	10	50	35	5	0	0	4.6	5.8
Rotary	0	33	47	20	0	0	7.6	6.1
Rocker	0	55	36	9	0	0	5.4	5.4
Thumbwheel	0	33	25	42	0	0	9.4	7.7
Snap action	0	46	36	18	0	0	6.7	6.5
Momentary	0	58	25	17	0	0	5.9	6.3
Dual in-line	0	55	27	18	0	0	6.1	6.6
WIRE AND CABLE								
Coaxial	15	54	31	0	0	0	3.6	4.2
Flat ribbon	12	65	23	0	0	0	3.1	5.5
Multiconductor	13	47	40	0	0	0	4.1	4.6
Hookup	35	40	25	0	0	0	2.8	3.2
Wire wrap	31	46	23	0	0	0	2.8	4.2
Power cords	18	65	12	5	0	0	3.1	5.9
POWER SUPPLIES								
Switcher	7	43	21	22	7	0	7.9	7.4
Linear	0	29	50	14	7	0	8.6	7.7
CIRCUIT BREAKERS								
	20	27	13	33	7	0	8.7	8.0
HEAT SINKS								
	7	53	27	13	0	0	5.3	5.1
RELAYS								
General purpose	12	47	18	23	0	0	6.1	6.1
PC board	6	28	33	33	0	0	8.5	7.2

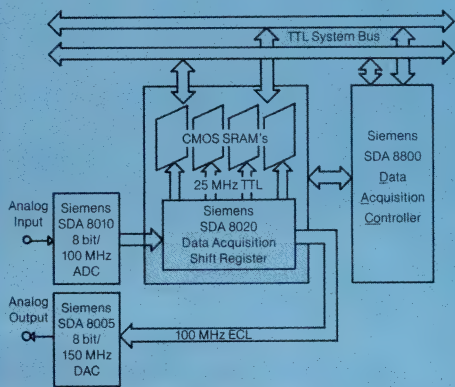
ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Last month's average (weeks)	Average (weeks)
RELAYS								
Dry reed	0	23	31	31	15	0	11.8	8.6
Mercury	0	25	38	25	12	0	10.7	9.1
Solid state	0	25	33	33	9	0	10.8	8.9
DISCRETE SEMICONDUCTORS								
Diode	23	36	18	14	4	5	7.0	7.0
Zener	5	44	17	22	6	6	9.2	7.3
Thyristor	7	27	33	33	0	0	8.5	8.8
Small signal transistor	13	37	31	13	6	0	6.9	7.4
MOSFET	0	37	36	27	0	0	7.9	10.2
Power, bipolar	0	45	18	37	0	0	8.3	9.3
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	7	20	40	27	6	0	9.5	9.6
CMOS	6	29	41	24	0	0	7.7	7.1
TTL	23	15	54	8	0	0	5.9	6.5
LS	21	22	43	14	0	0	6.1	5.9
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	10	40	40	10	0	0	5.6	8.7
OP amplifier	20	27	33	20	0	0	6.4	6.3
Voltage regulator	16	28	39	17	0	0	6.4	7.2
MEMORY CIRCUITS								
RAM 16k	11	34	22	33	0	0	7.7	9.7
RAM 64k	8	25	25	34	0	8	10.4	8.8
RAM 256k	7	14	36	0	14	29	15.8	10.0
RAM 1M-bit	0	13	37	0	25	25	17.5	12.5
ROM/PROM	0	34	33	22	0	11	10.3	11.0
EPROM 64k	0	25	42	25	0	8	10.3	9.5
EPROM 256k	0	42	25	25	0	8	9.3	9.3
EPROM 1M-bit	0	0	33	17	33	17	19.4	11.6
EEPROM 16k	0	13	37	37	0	13	13.2	10.6
EEPROM 64k	0	20	40	30	0	10	11.5	10.9
DISPLAYS								
Panel meters	9	36	46	9	0	0	5.8	6.7
Fluorescent	0	33	45	22	0	0	7.8	8.5
Incandescent	0	66	17	17	0	0	5.4	6.5
LED	10	53	21	16	0	0	5.3	8.1
Liquid crystal	15	15	39	31	0	0	8.4	10.5
MICROPROCESSOR ICs								
8-bit	0	34	58	8	0	0	6.6	7.6
16-bit	0	12	88	0	0	0	7.3	9.3
32-bit	0	0	78	22	0	0	9.8	7.6
FUNCTION PACKAGES								
Amplifier	0	22	45	33	0	0	9.3	6.4
Converter, analog to digital	8	17	42	25	8	0	9.8	8.6
Converter, digital to analog	10	20	30	40	0	0	9.2	9.2
LINE FILTERS								
	17	33	33	17	0	0	6.0	9.4
CAPACITORS								
Ceramic monolithic	6	55	33	6	0	0	4.7	5.8
Ceramic disc	12	47	24	17	0	0	5.8	5.1
Film	0	57	29	14	0	0	5.7	4.8
Aluminum electrolytic	5	47	27	21	0	0	6.5	4.8
Tantalum	0	47	29	24	0	0	7.1	6.2
INDUCTORS								
	0	42	42	16	0	0	6.8	9.3

Source: Electronics Purchasing magazine's survey of buyers

Our new HSDA chip set puts design waste in its place.

Now you can discard those space-robbing, power-hungry multichip designs for High Speed Data Acquisition (HSDA) and transmission!

Introducing Siemens remarkable new family of HSDA components...two highly integrated devices that can reduce your component count by 20 to 30 devices.



Intelligent μ P compatible Data acquisition/generation System

■ **SDA 8800 Data Acquisition Controller (DACO)**—
2 μ m CMOS-based, compact 68-pin package, interface compatible with all 8086, 80186, 80286 and 68000-based systems with 8-, 16- or 32-bit bus widths

■ **SDA 8020 Data Acquisition Shift Register (DASR)**
lets you read/write at 100 MHz multiplexed to 25 MHz. Compact 68-pin design, easily cascaded for large cache memory and/or even lower clock rates

■ **SDA 8200 A/D Converter** 6-bit flash converter, 300 MHz conversion rate, high-quality conversion up to the Nyquist frequency

■ **SDA 8005 D/A Converter** 8-bit resolution, 150 MHz conversion rate

■ **SDA 8010 A/D Converter** 8-bit flash converter, 100 MHz conversion rate

Put complicated high speed designs where they belong. Specify Siemens HSDA chip set...the efficient solution.

For more information, call (408) 980-4534 or write:
Siemens Semiconductor Group, Integrated Circuits, Data Acquisition Marketing Department,
2191 Laurelwood Road, Santa Clara, CA 95054

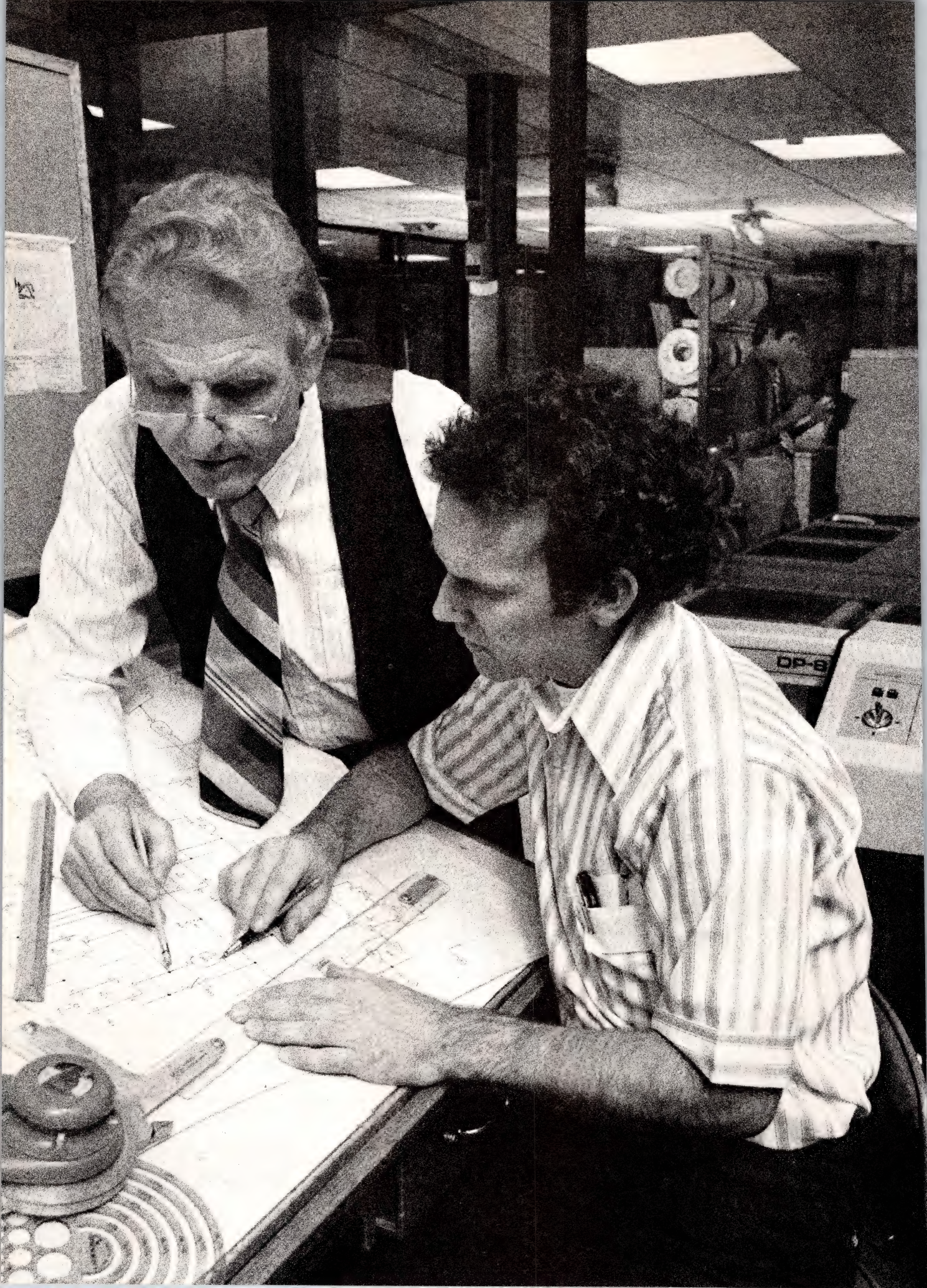
In Europe write: Siemens AG, Infoservice, Postfach 23 48, D-8510 Fuerth

Siemens National Distributors: Hall-Mark and Marshall
Siemens Regional Distributors: Advent Electronics, Inc., Almo Electronics,
Insight Electronics, Quality Components, Summit, Western Microtechnology.

Siemens...your partner for the future.

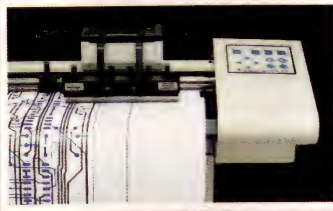
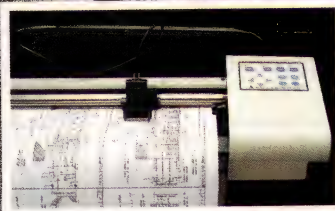
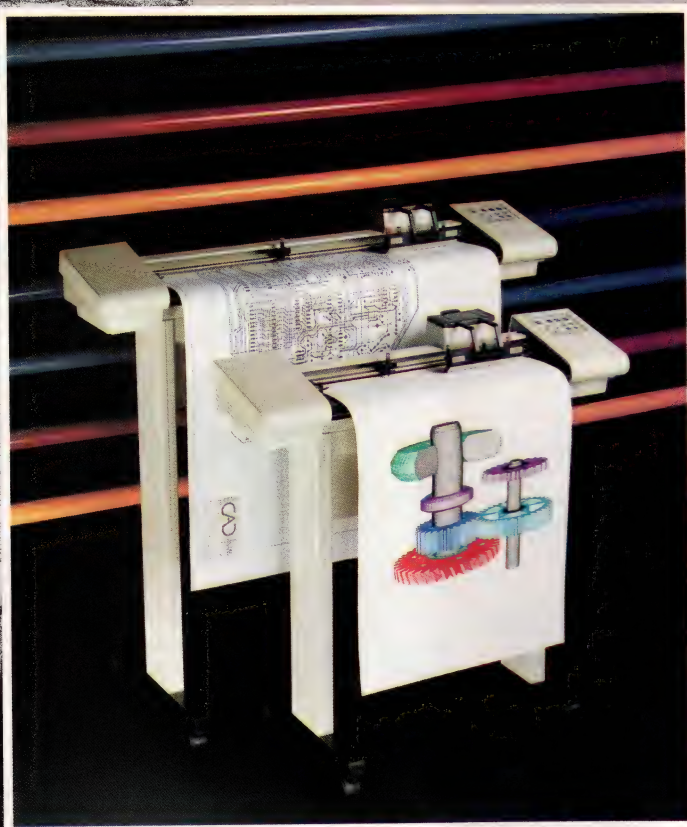
You'll appreciate the increased system performance. The added reliability. And of course, the miserly power consumption. What's more, you'll get all this efficiency without sacrificing the high-speed performance necessary for today's video, imaging and digital signal processing applications.





**For nearly
three decades,
companies
have drawn
on Houston
Instrument.**

**Now it's
your turn.**



*Houston Instrument, PRIORITY RESPONSE, and
SCAN-CAD are trademarks of AMETEK, Inc.*

Select a Houston Instrument™ plotter, and you're not only opting for the best price/performance on the market—you're choosing an industry leader with a proven track record. For nearly 30 years, companies have relied on HI for quality products, reliable service, and attractive prices.

Take HI's sleek new DMP-60 Series plotters—they're designed to impress even the most demanding CAD professional. Industry experts agree:

"Houston Instrument's DMP-61 delivers a remarkable combination of high speed, gorgeous plots, and very competitive price."



*Editor's Choice
Dec. 22, 1987*

HI's commitment to solid, innovative products is underlined by designed-in versatility. The SCAN-CAD™ option lets a DMP-60 Series plotter double as a scanner. The Multi-Pen accessory speeds colorful, complex drawings. And HI's one megabyte buffer board lets the DMP-60 Series plot several originals—without tying up your computer.

Proven performance, proven value—that's HI plotters. Flexible. Fast. Accurate. Software compatible. Reliable. And backed by HI's PRIORITY RESPONSE™ customer support programs which include overnight product-replacement service, leasing, and warranty coverage.

All this from an industry leader that companies have drawn on for nearly three decades—Houston Instrument.

Now it's your turn. Begin by calling 1-800-444-3425 or 512-835-0900 or writing Houston Instrument, 8500 Cameron Road, Austin, Texas 78753.

**HOUSTON
INSTRUMENT**
A DIVISION OF **AMETEK**

CIRCLE NO 77

TOSHIBA. NOW, 1 MB DRAMS



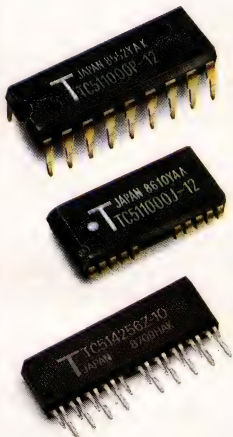
AREA SALES OFFICES: CENTRAL AREA, Toshiba America, Inc., (312) 945-1500; EASTERN AREA, Toshiba America, Inc., (617) 272-4352; NORTHWESTERN AREA, Toshiba America, Inc., (408) 737-9844; SOUTHWESTERN REGION, Toshiba America, Inc., (714) 259-0368; SOUTH CENTRAL REGION, Toshiba America, Inc., (214) 480-0470; SOUTHEASTERN REGION, Toshiba America, Inc., (404) 368-0203; MAJOR ACCOUNT OFFICE, Fishkill, New York, Toshiba America, Inc., (914) 896-6500; BOCA RATON, FLORIDA, Toshiba America, Inc., (305) 394-3004. **REPRESENTATIVE OFFICES:** ALABAMA, Montgomery Marketing, Inc., (205) 830-0498; ARIZONA, Summit Sales, (602) 998-4850; ARKANSAS, MIL-REP Associates, (512) 346-6331; CALIFORNIA (Northern) Elrepro, Inc., (415) 962-0660; CALIFORNIA (L.A. & Orange County) Bager Electronics, Inc., (818) 712-0011, (714) 957-3367, (San Diego County) Eagle Technical Sales, (619) 743-6550; COLORADO, Straube Associates Mountain States, Inc., (303) 426-0890; CONNECTICUT, Datcom, Inc., (203) 288-7005; FLORIDA, Sales Engineering Concepts, (305) 426-4601, (305) 682-4800; GEORGIA, Montgomery Marketing, Inc., (404) 447-6124; IDAHO, Components West, (509) 922-2412; ILLINOIS, Carlson Electronic Sales, (312) 956-8240, R.W. Kunz, (314) 966-4977; INDIANA, Leslie M. DeVoe Company, (317) 842-3245; IOWA, C.H. Horn, (319) 393-8703; KANSAS, D.L.E. Electronics, (316) 744-1229; KENTUCKY, Leslie M. DeVoe Company, (317) 842-3245; LOUISIANA, MIL-REP Associates, (713) 444-2557; MAINE, Datcom, Inc., (617) 891-4600; MASSACHUSETTS, Datcom, Inc., (617) 891-4600; MICHIGAN, Action Components Sales, (313) 349-3940; MINNESOTA, Electric Component Sales, (612) 933-2594;

FIRST AGAIN. AND 256 K CRAMS.

Toshiba technology leads the way again with the development of Ultra Large Scale memory devices that feature high speed access times.

1 MB CMOS DRAMS

Toshiba, world production leader in CMOS, is delivering 1MB DRAMs. In three different access modes. With speeds of 85, 100 and 120 ns. You have a choice of fast page mode, static column or nibble mode, as well as DIP, SOJ and ZIP packages.



TOSHIBA DYNAMIC RAMS							
Part Number	Org.	Process	Samples	Prod.	Speed Sorts Available	Pkg Options & Comments	
TC511000P/J/Z	1MbX1	CMOS	YES	YES	85 100 120	P/J/Z	
TC511000AP/AJ/AZ	1MbX1	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC511001P/J/Z	1MbX1	CMOS	YES	YES	85 100 120	P/J/Z	
TC511001AP/AJ/AZ	1MbX1	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC511002P/J/Z	1MbX1	CMOS	YES	YES	85 100 120	P/J/Z	
TC511002AP/AJ/AZ	1MbX1	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC514256P/J/Z	256KX4	CMOS	YES	YES	85 100 120	P/J/Z	
TC514256AP/AJ/AZ	256KX4	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC514266AP/AJ/AZ	256KX4	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC514258P/J/Z	256KX4	CMOS	YES	YES	85 100 120	P/J/Z	
TC514258AP/AJ/AZ	256KX4	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC514268AP/AJ/AZ	256KX4	CMOS	4/88	5/88	70 80 100	P/J/Z	
TC524256P/J/Z	256KX4	CMOS	YES	2Q/88	100 120	P/J/Z	
TC524257P/J/Z	256KX4	CMOS	YES	2Q/88	100 120	P/J/Z	
TC521000P	256KX4	CMOS	YES	YES	N/A	P	
TC41000L	1MbX4	CMOS	6/88	7/88	70 80 100	L	
THM81000S/L	1MbX8	CMOS	YES	YES	85 100 120	S/L	
THM91000S/L	1MbX9	CMOS	YES	YES	85 100 120	S/L	
THM91020L	1MbX9	CMOS	2/88	4/88	70 80 100	L	
THM8512L	512KX8	CMOS	YES	YES	85 100 120	L	

© 1988 Toshiba America, Inc.

256K CMOS STATIC RAM



Toshiba's product development leadership continues. We were first with 16K CMOS RAMs.

First with 64K CMOS RAMs. And now first again—with 256K CMOS static RAMs. This 32K x 8 device features the lowest power consumption available today—only 5mA/MHz. Lower than any competitive product. And we offer speeds to 85 ns.

TOSHIBA 256K CRAMS					
Part Number	Org.	Process	Speed	Standby Power	Package
TC55257APL-85	32KX8	CMOS	85ns	100µAMAX	28PIN
TC55257APL-10	32KX8	CMOS	100ns	100µAMAX	28PIN
TC55257APL-12	32KX8	CMOS	120ns	100µAMAX	28PIN
TC55257APL-85L	32KX8	CMOS	85ns	30µAMAX	28PIN
TC55257APL-10L	32KX8	CMOS	100ns	30µAMAX	28PIN
TC55257APL-12L	32KX8	CMOS	120ns	30µAMAX	28PIN

(AVAILABLE IN PLASTIC DIP AND SOG)

ULTRA LEADERSHIP

Again Toshiba leads the way. With high speed access times. Now with Ultra Large Scale products. With ultra high quality. Toshiba. The power in memories.

TOSHIBA. THE POWER IN MEMORIES.
TOSHIBA AMERICA, INC.

MISSISSIPPI, Montgomery Marketing, Inc., (205) 830-0498; MISSOURI, D.L.E. Electronics, (316) 744-1229; R.W. Kunz, (314) 966-4977; MONTANA, Components West, (206) 885-5880; NEVADA, Elreco, Inc., (415) 962-0660; NEBRASKA, D.L.E. Electronics, (316) 744-1229; NEW ENGLAND, Datcom, Inc., (617) 891-4600; NEW HAMPSHIRE, Datcom, Inc., (617) 891-4600; NEW JERSEY, Nexus Technology, (201) 947-0151; NEW MEXICO, Summit Sales, (602) 998-4850; NEW YORK, Nexus Technology, (201) 947-0151; PI-tronics, (315) 455-7346; NORTH CAROLINA/SOUTH CAROLINA, Montgomery Marketing, Inc., (919) 467-6319; NORTH DAKOTA/SOUTH DAKOTA, Electric Component Sales, (612) 933-2594; OHIO, Steffen & Associates, (216) 461-8333; (419) 884-2313; (513) 293-3145; OKLAHOMA, MIL-REP Associates, (214) 644-6731; OREGON, Components West, (503) 684-1671; PENNSYLVANIA, Nexus Technology, (215) 675-9600; Steffen & Associates, (412) 276-7366; RHODE ISLAND, Datcom, Inc., (617) 891-4600; TENNESSEE, Montgomery Marketing, Inc., (205) 830-0498; TEXAS, MIL-REP Associates, (512) 346-6331, (713) 444-2557, (214) 644-6731; UTAH, Straube Associates Mountain States, Inc., (801) 263-2640; VERMONT, Datcom, Inc., (617) 891-4600; WEST VIRGINIA, Steffen & Associates, (419) 884-2313; WASHINGTON, Components West, (206) 885-5880, (509) 922-2412; WISCONSIN, Carlson Electronics, (414) 476-2790, Electric Component Sales, (612) 933-2594; WYOMING, Straube Associates Mountain States, Inc., (303) 426-0890; CANADA, BRITISH COLUMBIA, Components West, (206) 885-5880; ONTARIO, Electro Source, Inc., (416) 675-4490, (613) 726-1452.

Choose Teledyne First!

AUTHORIZED DISTRIBUTORS

Alabama

Marshall Industries
Huntsville, AL
(205) 881-9235
Quality Components
Huntsville, AL
(205) 830-1881

Arizona

Future/Cetec Electronics
Phoenix, AZ
(602) 968-7140
Marshall Industries
Phoenix, AZ
(602) 496-0290

California

All American
Torrance, CA
(213) 320-0240
All American
San Jose, CA
(408) 287-0190
Future Electronics
San Jose, CA
(408) 434-1114
Marshall Industries
Milpitas, CA
(408) 942-4600
Marshall Industries
Rancho Cordova, CA
(916) 635-9700
Future/Cetec Electronics
Chatsworth, CA
(818) 700-0914
Marshall Industries
Chatsworth, CA
(818) 407-0101
Marshall Industries
El Monte, CA
(818) 459-5500
Future/Cetec Electronics
Irvine, CA
(714) 250-4141
Marshall Industries
Irvine, CA 92718
(714) 859-5050
Future/Cetec Electronics
San Diego, CA
(619) 278-5020
Marshall Industries
San Diego, CA
(619) 578-9606
Micro-Die Systems
Torrance, CA
(213) 373-0687

Colorado

Future Electronics
Westminster, CO
(303) 650-0123
Marshall Industries
Thornton, CO
(303) 451-8383

Connecticut

Future Electronics
Bethel, CT
(203) 743-9594
Marshall Industries
Wallingford, CT
(203) 265-3822

Florida

All American
Miami, FL
(305) 621-8282
Chip Supply
Orlando, FL
(305) 298-7100
Future Electronics
Clearwater, FL
(813) 578-2770
Future Electronics
Altamonte Springs, FL
(305) 767-8414
Marshall Industries
Ft. Lauderdale, FL
(305) 977-4880
Marshall Industries
Altamonte Springs, FL
(305) 767-8585
Marshall Industries
St. Petersburg, FL
(813) 576-1399
Quality Components
Tampa, FL
(813) 854-2614

Georgia

Future Electronics
Norcross, GA
(404) 441-7676
Marshall Industries
Norcross, GA
(404) 923-5750
Quality Components
Norcross, GA
(404) 449-9508

Illinois

Advent Electronics
Rosemont, IL
(312) 298-4210
Future Electronics
Schaumburg, IL
(312) 882-1255
Marshall Industries
Schaumburg, IL
(312) 490-0155

Indiana

Advent Electronics
Indianapolis IN
(317) 872-4910
Marshall Industries
Indianapolis, IN
(317) 297-0483

Iowa

Advent Electronics
Cedar Rapids, IA
(319) 363-0221

Kansas

Marshall Industries
Lenexa, KS
(913) 492-3121

Maryland

All American
Rockville, Maryland
(301) 251-1205
Future Electronics
Columbia, MD
(301) 995-1222

Marshall Industries
Gaithersburg, MD
(301) 840-9450
Pyttronic Industries
Savage, MD
(301) 792-0780

Massachusetts

Now Electronics
Framingham, MA
(617) 872-5876
Future Electronics
Westborough, MA
(617) 366-2400
Marshall Industries
Wilmington, MA
(617) 658-0810

Michigan

Advent Electronics
Farmington Hill, MI
(313) 477-1650
Marshall Industries
Livonia, MI
(313) 525-5850
Future Electronics
Detroit, MI
(313) 261-5270

Minnesota

All American
Minneapolis, MN
(612) 884-2220
Marshall Industries
Plymouth, MN
(612) 559-2255
Future Electronics
Eden Prairie, MN
(612) 944-2200

Missouri

Marshall Industries
Bridgeton, MO
(314) 291-4650

New Jersey

Future Electronics
Mt. Laurel, NJ
(609) 778-7600
Marshall Industries
Mt. Laurel, NJ
(609) 234-9100
Future Electronics
Fairfield, N.J.
(201) 227-4346
Marshall Industries
Fairfield, NJ
(201) 882-0320

New York

All American
Ronkonkoma, NY
(516) 981-3935
Future Electronics
Liverpool, NY
(315) 451-2371
Future Electronics
Rochester, NY
(716) 272-1120
Marshall Industries
Hauppauge, LI, NY
(516) 273-2424
Marshall Industries
Johnson City, NY
(607) 798-1611

Marshall Industries
Rochester, NY
(716) 235-7620
Future Electronics
Hauppauge, NY
(516) 234-4000

North Carolina

Marshall Industries
Raleigh, N.C.
(919) 878-9882
Quality Components
Raleigh, N.C.
(919) 876-7767
Future Electronics
Charlotte, N.C.
(704) 529-5500

Ohio

Hughes-Peters, Inc.
Cincinnati, OH
(513) 351-2000
Hughes-Peters Inc.
Columbus, OH
(614) 294-5351
Marshall Industries
Dayton, OH
(513) 898-4480
Marshall Industries
Solon, OH
(216) 248-1788
Marshall Industries
Westerville, OH
(614) 891-7580

Oklahoma

Quality Components
Tulsa, OK
(918) 664-8812

Oregon

Cetec Future
Beaverton, OR
(503) 645-9454
Marshall
Beaverton, OR
(503) 644-5050

Pennsylvania

Marshall Industries
Pittsburgh, PA
(412) 963-0441
Pyttronic Industries
Montgomeryville, PA
(213) 643-2850

Texas

All American
Richardson, TX
(800) 541-1435
Future Electronics
Richardson, TX
(214) 437-2437
Marshall Industries
Austin, TX
(512) 837-1991
Marshall Industries
Carrollton, TX
(214) 233-5200
Marshall Industries
Houston, TX
(713) 895-9200
Marshall Industries
El Paso, TX
(915) 593-0706

Marshall Industries
Brownsville, TX
(512) 542-4589
Quality Components
Addison, TX
(214) 733-4300
Quality Components
Austin, TX
(512) 835-0220
Quality Components
Sugarland, TX
(713) 491-2255

Utah

Future Electronics
Salt Lake City, UT
(801) 972-8489
Marshall Industries
Salt Lake, UT
(801) 485-1551

Washington

Future Electronics
Redmond, WA
(206) 881-8199
Marshall Industries
Bellevue, WA
(206) 747-9100

Wisconsin

Marshall Industries
Brookfield, WI
(414) 797-8400
Taylor Electronic Co.
Mequon, WI
(414) 241-4321

Alberta

Future Electronics
Calgary Alberta
(403) 235-5325
Future Electronics
Edmonton, Alberta
(403) 438-2858

British Columbia

Future Electronics
Vancouver, B.C.
(604) 294-1166

Ontario

Future Electronics
Ottawa, Ontario
(613) 820-8313
Future Electronics
Dowdview, Ontario
(416) 638-4771

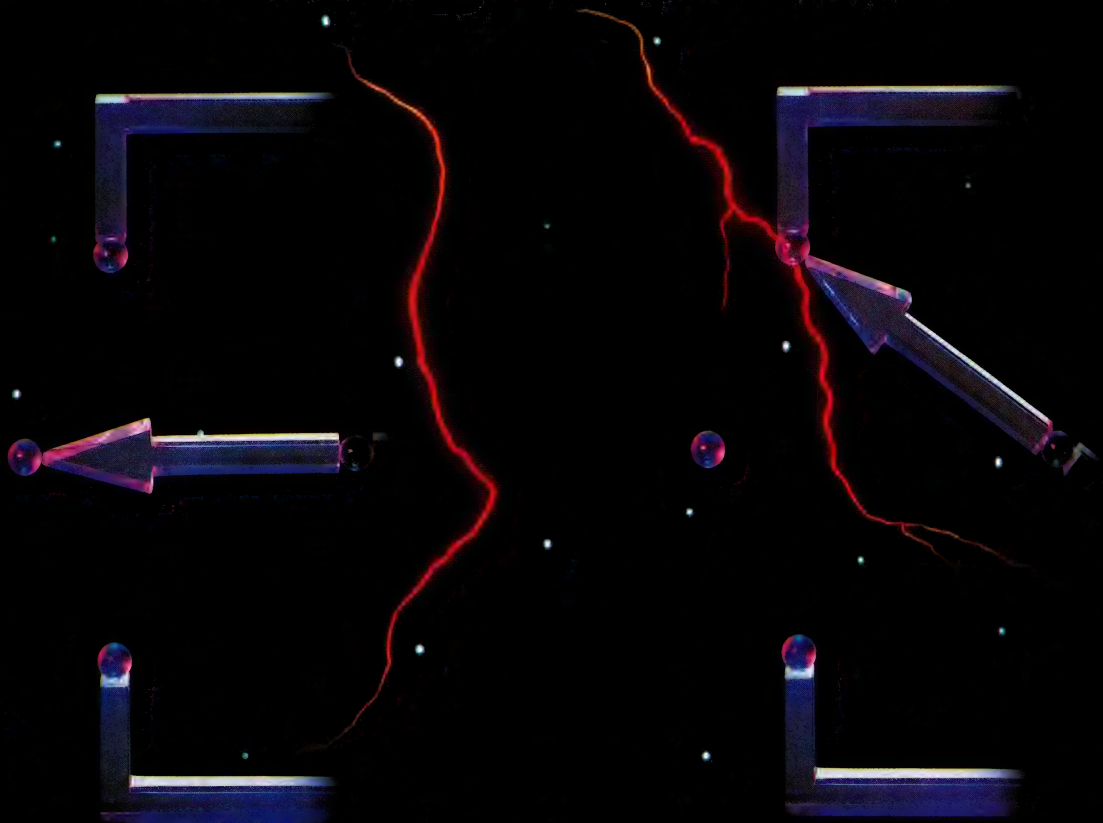
Quebec

Future Electronics
Pointe Claire, Quebec
(514) 694-7710
Future Electronics
St. Foy, Quebec
(418) 682-5775

Manitoba

Future Electronics
Winnipeg, Manitoba
(204) 339-0554

Seeking a +5V Supply Voltage Analog Switch? They Exist Here!

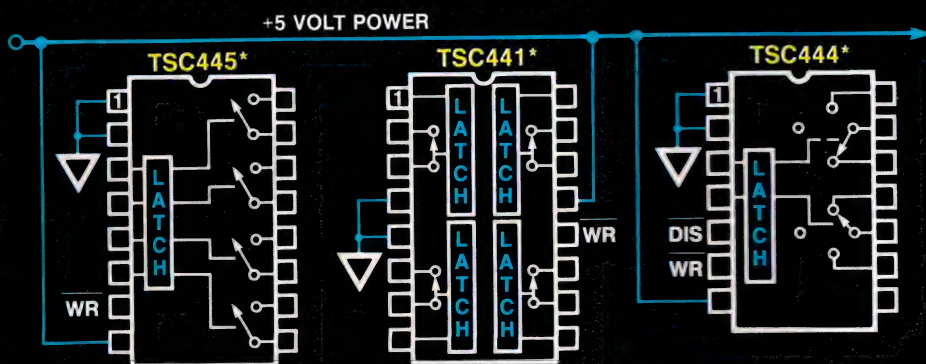


Teledyne Semiconductor's **TSC44X** precision **CMOS** analog switch family sets the standard in low supply voltage switch technology. Sharing the same 5V or $\pm 5V$ power supply levels modern CMOS data converters and operational amplifiers need, your designs now benefit from low 10 pA switch leakage current, 95 ohm "ON" resistance, and 1.5mW power dissipation. Single supply operation from 3 to 18V for battery powered systems. Full microprocessor compatibility too!

Switch architectures cover all your application needs from quad **SPST** to dual **SPDT**. Normally closed, open and mixed versions. The innovative **TSC444 SPDT** switch features a neutral, switch "OFF" position. On chip latches eliminate external components in μ -processor controlled systems. Disable latches for transparent operation. Standardize on the **TSC44X** family for your job today and tomorrow's breakthrough.

Pin compatible with many old, high supply voltage only parts like the DG221 and AD7590/1/2. Available in DIP or "SO" surface mount technology. Call or write for full information, design help and data sheets. Samples available now.

All devices are backed by Teledyne's reputation for quality, service and support - a reputation earned through 25 leadership years in the semiconductor industry.



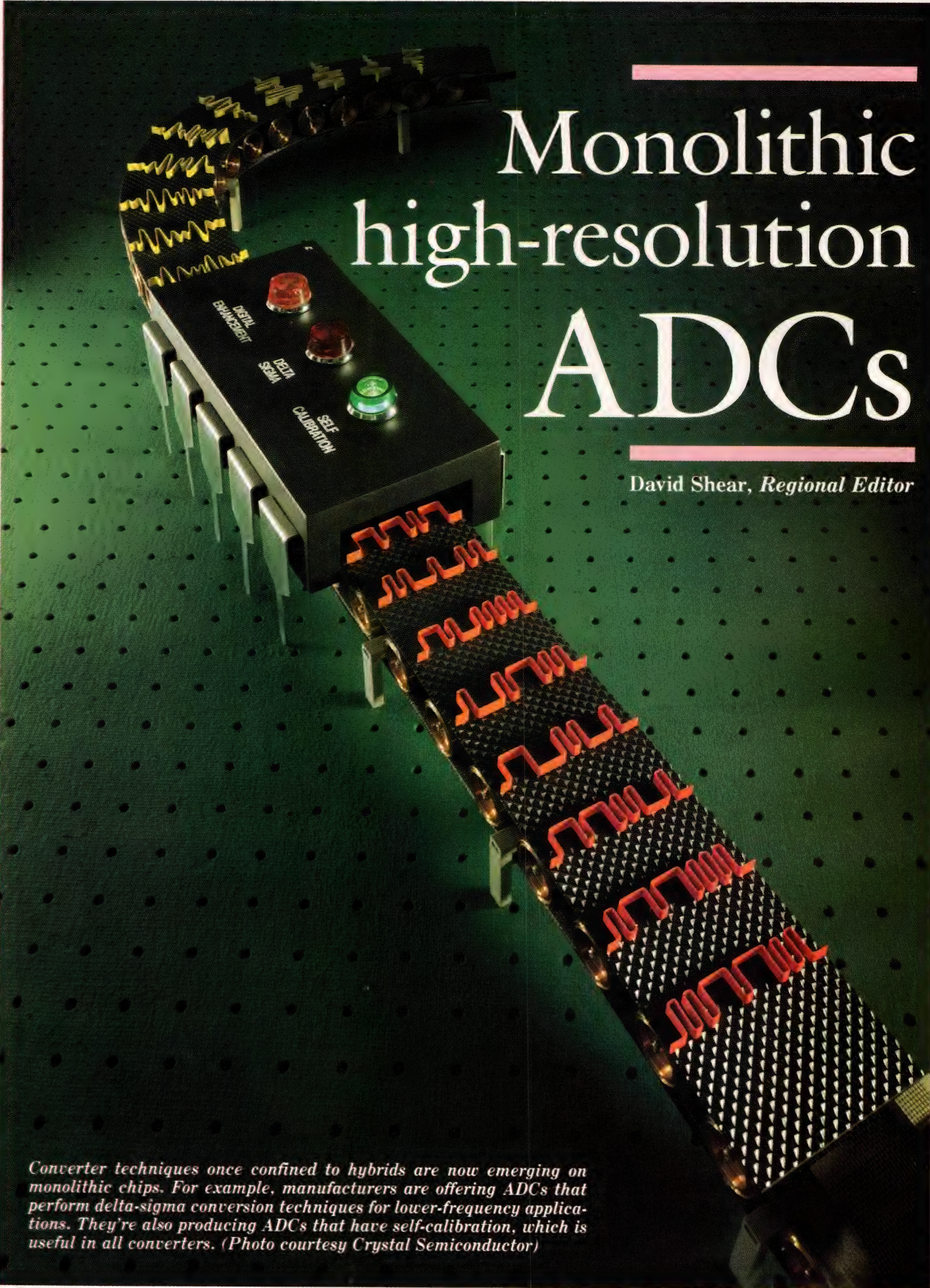
*All Configurations Available

CIRCLE NO 79

1-800-888-9966
415-968-9241

1300 Terra Bella Avenue
Mountain View, CA 94039
TWX: 910-379-6494
FAX: 415-967-1590

 **TELEDYNE
SEMICONDUCTOR**



Monolithic high-resolution ADCs

David Shear, *Regional Editor*

Converter techniques once confined to hybrids are now emerging on monolithic chips. For example, manufacturers are offering ADCs that perform delta-sigma conversion techniques for lower-frequency applications. They're also producing ADCs that have self-calibration, which is useful in all converters. (Photo courtesy Crystal Semiconductor)

SPECIAL REPORT

Improved manufacturing processes are already allowing manufacturers to realize innovative high-resolution-ADC designs on monolithic chips. Because ADC improvements will now be driven by architectural changes, you can expect to see phenomenal gains in these chips' performance in the near future.

Until the past year, engineers have had to stockpile their most innovative A/D-converter designs, because the available manufacturing processes simply couldn't put those designs onto monolithic chips economically. In fact, except for the introduction of successive-approximation, integrating, and flash ADCs, the electronics industry saw no major changes in monolithic ADCs in the past 10 years.

Now, however, the manufacturing processes have finally caught up with the technology: Manufacturers are placing complex, high-speed designs on monolithic chips. ADC techniques first described years, if not decades, ago are now finding their way to monolithic devices, and the ADCs are reaping increased speed and resolution from these architectural changes. And as architectural innovation continues, you'll see the trend of the past year continuing: Monolithic ADCs will continue to make quantum leaps in performance.

Recently, for example, manufacturers have introduced subranging flash ADCs, self-calibrating ADCs, and delta-sigma ADCs, all monolithics. The subranging-flash conversion method will yield a great increase in ADC speed; delta-sigma conversion techniques will lead to much higher resolution.

Furthermore, papers presented at the 1987 and 1988 International Solid-State Circuits Conferences (ISSCCs) have offered a glimpse of future ADC technology. Highly parallel, pipelined subranging flash ADCs will be the rule for high-speed, high-resolution ADCs, and oversampling delta-sigma converters will take over the dc and lower-band audio applications. Crystal Semiconductor, for example, already offers products based on these two architectures.

12- and 16-bit ADC prices will plummet

You can expect manufacturers to introduce many high-resolution converters during the next few years. These new ADCs will provide the performance of

earlier high-resolution ADCs—which were pricey, multiple-chip devices—yet will offer the benefits of monolithics: lower price, lower power consumption, and alternate sources. Consumer digital audio equipment will provide a major application for these chips in the next few years; it will help to drive the price of 16-bit ADCs below that of today's 12-bit ADCs, thus forcing the price of 12-bit ADCs below \$10. As the price of 16-bit ADCs drops, many OEMs will expect their engineers to design with them.

You may question the possibility of designing with 16-bit converters: The noise and drift problems seem insurmountable. A 16-bit converter with a 10V range has a least significant bit (LSB) of 153 μ V; such a small voltage can easily be swamped by noise. To maintain the ADC's 16-bit accuracy, the reference of a 16-bit converter must have a temperature coefficient of at most 0.17 ppm/ $^{\circ}$ C (25 to 70 $^{\circ}$ C). These numbers do indeed sound insurmountable, but you can use certain techniques to take advantage of the full resolution of 16-bit ADCs.

16-bit converters suit DSP applications

Such converters are useful, for example, in DSP applications: Digital signal processors don't require absolute accuracy. The important criteria are the ADCs' dynamic specifications—their total harmonic distortion, S/N ratio, in-band harmonics, intermodulation distortion, and input bandwidth. By keeping the signal pure (low distortion) and the noise floor low enough to analyze the signal, you can meet the needs of your digital signal processor.

It's difficult to design a system that's absolutely accurate to 16 bits, but it can be done. You need to design with this goal in mind from the start, by using proper grounding, shielding, and system-design techniques. You can take many approaches, however: For example, you could design the system to work in

Upgrading a system design from 12 bits to 16 bits requires more than merely replacing the ADC—you must upgrade your design techniques as well.

thermal equilibrium and use self-calibration once the temperature is stable. If your application is a highly digital system, where noise is everywhere, you could design the system to shut down all of the digital circuitry that might cause interference during the conversion process, thereby eliminating that source of noise.

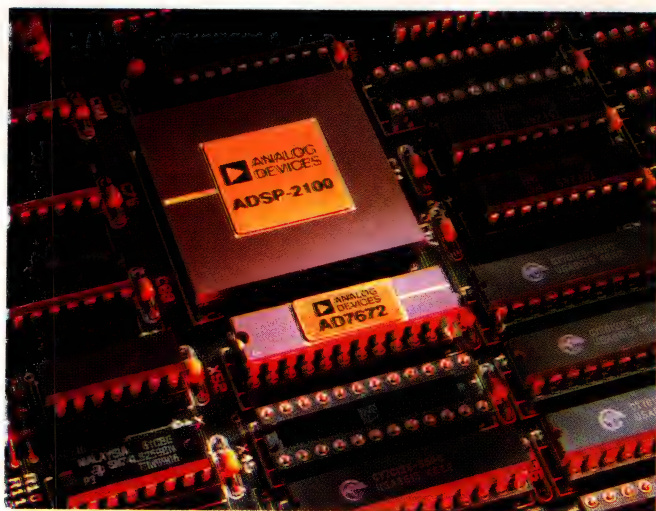
When you're upgrading your design from a 12-bit system to a 16-bit system, you have to do more than merely replace the ADC. Some higher-resolution ADCs, especially the serial variety, are pin compatible with their lower-resolution versions. When your system requirements move from 12 to 16 bits, the noise floor and temperature drift must decrease by a factor of 16 (the LSB goes from 2.4 mV to 153 μ V and the temperature coefficient goes from 2.7 to 0.17 ppm/ $^{\circ}$ C—this and other useful data is contained in a wall chart on data acquisition that's available from Datel). So even if you can use a 16-bit converter as a drop-in replacement for a 12-bit one, it's doubtful that your system will be accurate to 16 bits without considerable redesign.

Don't overkill on speed or resolution

When determining the conversion time your application will require of an ADC, keep the Nyquist criterion in mind—you must sample at a frequency at least twice that of the highest frequency of the input. In other words, you must filter the input so that the signals above half the sample rate are less than 1 LSB.

It is possible to *undersample*, which is to acquire data above the Nyquist frequency. If the incoming signal is band-limited so that it's between the sampling frequency and half of the sampling frequency, you can undersample the signal and extract the desired data.

Many applications require you to know the input bandwidth of the ADC, though it rarely appears on data sheets. Many ADCs have a bandwidth that's about half the sample rate. That bandwidth is sometimes not adequate. The bandwidth is a measure of the frequency at which the amplitude is attenuated by 3 dB; however, attenuation actually begins at a much lower frequency. If you desire the amplitude of the signal to be constant across your band of interest, the system's response will be off by the lower frequency at which attenuation actually begins. Also, when you multiplex the input, the input to the ADC could change from the negative rail to the positive rail as you switch inputs. The maximum slew rate of the input will determine the settling time of switching inputs, which you must add to the total conversion time (or which you must overlap with the



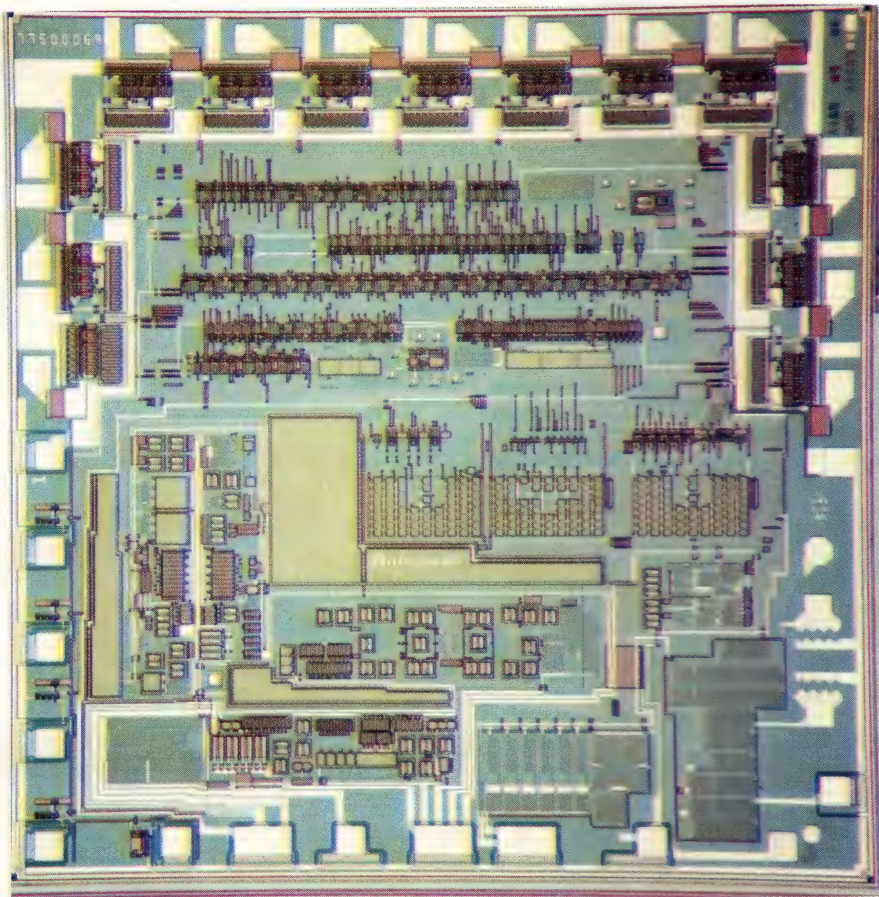
Engineers are using ADCs in DSP applications, whose specification requirements differ from those of traditional, static-measurement applications. To facilitate your selection of an ADC for DSP applications, many manufacturers are placing dynamic specifications on ADC data sheets. (Photo courtesy Analog Devices)

conversion process if you're using an S/H amplifier).

Soon, all ADCs' data sheets will include the parts' bandwidth and other information useful in DSP applications. To ascertain the absolute accuracy of an ADC, manufacturers perform static testing on the devices. The traditional static tests don't determine an ADC's dynamic performance, however. If you're going to use the ADC in DSP applications, you need to perform dynamic testing to determine an ADC's signal-to-noise ratio, total harmonic distortion, intermodulation distortion, effective number of bits, and differential nonlinearity (Ref 1). Because it's costly to test ADCs, most manufacturers don't perform both static and dynamic testing on the same device. Crystal Semiconductor, however, offers two versions of each ADC it sells: The devices are identical except that the company performs static testing on one and dynamic testing on the other. In the future, you can expect to see dynamic-test data from all ADC manufacturers.

ADC manufacturers will also continue the trend toward including many functions on a single chip. For example, a complete data-acquisition system on a chip will include signal-conditioning circuitry, a multiplexer, an S/H amplifier, an ADC, and digital-control and interface circuitry. Vendors have been putting such complete data-acquisition systems into hybrid devices for some time, and it won't be long before they'll be able to fit the same circuitry on monolithic chips.

Another function that's finding its way onto mono-



This typical capacitive-DAC-based ADC—the Honeywell HADC574Z—uses successive approximation, today's most dominant conversion technique. As this die shot shows, the chip's circuitry is mostly analog.

lithic ADCs is sample-and-hold amplification. It has always been time consuming—and it's sometimes been costly—to design an S/H amplifier for a particular application (Ref 2). Many of today's ADCs solve that problem by including built-in S/H amplifiers. You must look carefully at these ADCs' data sheets, however, because in most cases, the S/H amplifiers are part of the conversion process and don't allow you to use very high frequencies. The limiting factor in S/H amplification is usually the aperture uncertainty or aperture jitter, which is the timing jitter that occurs during the transition from sample to hold.

The maximum frequency that an S/H amplifier can accurately work with is limited by the need to keep the input voltage within 1 LSB during the aperture-uncertainty time. For example, Honeywell's 12-bit HADC574Z ADC has a 25- μ sec conversion time, and its S/H function has 3- μ sec acquisition time, which would theoretically allow for 35.7-kHz throughput. The S/H amplifier's aperture uncertainty is 20 nsec, which limits the input frequency to less than 2 kHz. When the input

is band-limited below 2 kHz, the internal S/H amplifier is enough; however, when the input is above this frequency, you must use an external S/H amplifier as well. Soon, manufacturers will begin to offer ADCs with good on-chip S/H amplifiers that are tuned to the ADCs, ensuring accurate performance.

Some ADCs offer on-chip references

ADC manufacturers have also begun to put voltage references on ADC chips. To maintain an ADC's 12-bit accuracy over 0 to 70°C, a voltage reference must have a temperature coefficient of less than 2 ppm/°C. However, most of the on-chip references available now have temperature coefficients of about 10 times that value, so they're not particularly accurate. For certain applications, therefore, you may elect to use an external reference as well. (See Ref 3 for more information about selecting a voltage reference.)

For ADCs that have resolutions greater than 12 bits, however, an external reference may itself cause problems. The circuit path between the reference and the

REPRESENTATIVE MONOLITHIC HIGH-RESOLUTION A/D CONVERTERS

MANUFACTURER AND MODEL	RESOLUTION (BITS)	THROUGHPUT/ CONVERSION TIME	INPUT- VOLTAGE RANGE	POWER SUPPLY (V)	POWER DISSIPATION (mW)	INTERNAL REFERENCE	S/H AMPLIFIER
ANALOG DEVICES							
AD674A	12	15 μ SEC	0 TO 10, 20 $\pm$ 5, $\pm$ 10	$\pm$ 12 OR $\pm$ 15	390 TYP	•	
AD7550	13	40 mSEC	—	$\pm$ 5, +12	44 MAX		NA
AD7552	12 PLUS SIGN	160 mSEC	—	$\pm$ 5, +12	40 MAX		NA
AD7572	12	5 μ SEC	0 to 5, $\pm$ 2.5	+5, -15	215 MAX	•	
AD7672	12	3 μ SEC	0 TO 5, 10, $\pm$ 5	+5, -12	179 MAX		
BURR-BROWN							
ADC80MAH-12	12	25 μ SEC	$\pm$ 2.5, $\pm$ 5, $\pm$ 10, 0 TO 5, 10	+5, $\pm$ 12, OR $\pm$ 15	705 MAX	•	
CRYSTAL SEMICONDUCTOR							
CS5012/CSZ5112	12	100 kHz	$\pm$ 5	$\pm$ 5	250 MAX		•
CS5014/CSZ5114	14	56 kHz	$\pm$ 5	$\pm$ 5	250 MAX		•
CS5016/CSZ5116	16	50 kHz	$\pm$ 5	$\pm$ 5	250 MAX		•
CSZ5126	16	100 kHz	$\pm$ 5	$\pm$ 5	250 MAX		•
CSZ5316	16	20 kHz	$\pm$ 2.75	$\pm$ 5	250 MAX	•	•
CSZ5412	12	1 MHz	0 TO 3, $\pm$ 1.5	$\pm$ 5	700 TYP		•
CS5501	16	4 kHz (10-Hz MAX BANDWIDTH)	0 TO 4.5, $\pm$ 4.5	$\pm$ 5	40 TYP		
DATTEL							
ADC EK12B	12	24 mSEC	0 TO 10, $\pm$ 5	$\pm$ 5	50 MAX		NA
ADC ET12B	12	24 mSEC	0 TO 10, $\pm$ 5	$\pm$ 5	50 MAX		NA
ADC 800	15 PLUS SIGN	400 mSEC	$\pm$ 5	$\pm$ 5	35 MAX		NA
ADC 7109	12 PLUS SIGN	33 mSEC	$\pm$ 5	$\pm$ 5	15 MAX	•	NA
GE SOLID STATE							
ICL7112	12	40 μ SEC	0 TO -10, 0 TO 10	$\pm$ 5	60 MAX		
ICL7115	14	40 μ SEC	0 TO -5, 0 to 5	$\pm$ 5	60 MAX		
HONEYWELL							
HADC574Z	12	35.7 kHz	0 TO 10, 20, $\pm$ 5, $\pm$ 10	5, 12, OR 15	150 MAX	•	•
HADC674Z	12	59.5 kHz	0 TO 10, 20, $\pm$ 5, $\pm$ 10	5, 12, OR 15	150 MAX	•	•
HYBRID SYSTEMS							
HS574A	12	35.7 kHz	0 TO 10, 20, $\pm$ 5, $\pm$ 10	5, 15	150 MAX	•	•
SP674A	12	59.5 kHz	0 TO 10, 20, $\pm$ 5, $\pm$ 10	5, 15	150 MAX	•	•
MAXIM INTEGRATED PRODUCTS							
MAX162	12	3 μ SEC	0 TO 5	5, -15	215 MAX	•	
MAX170	12	5 μ SEC	0 TO 5	5, -15	250 MAX	•	
AD7572-5	12	5 μ SEC	0 TO 5	5, -15	215 MAX	•	
MAX7109	12	33 mSEC	$\pm$ 5	$\pm$ 5	15 MAX	•	NA
MAX133/134	3 $\frac{1}{2}$ -DIGIT	50 mSEC	$\pm$ 4 TO $\pm$ 4000	$\pm$ 5 OR +9	2.25 MAX		NA

NOTES:

LCC = LEADLESS CHIP CARRIER
 PLCC = PLASTIC LEADED CHIP CARRIER
 SO = SMALL-OUTLINE PACKAGE
 NA = NOT APPLICABLE

INPUT CHANNELS	PARALLEL I/O	WORD WIDTH	SERIAL I/O	SELF-CALIBRATION	PACKAGE	PRICE (100)
1	•	8 OR 12			28-PIN DIP	\$39.25
1	•	8 OR 13			40-PIN DIP	\$26.30
1	•	8 OR 13			40-PIN DIP	\$10.45
1	•	12			24-PIN, 0.3-IN. DIP 28-PIN LCC	\$46
1	•	12			24-PIN, 0.3-IN. DIP, 28-PIN PLCC OR LCC	\$75
1	•	12	•		32-PIN DIP	\$35
1	•	8 OR 16	•	•	40-PIN DIP	\$25.90
1	•	8 OR 16	•	•	40-PIN DIP	\$45
1		8 OR 16	•	•	40-PIN DIP	\$69
2		—	•	•	28-PIN DIP	\$39.90
1		—	•		18-PIN DIP	\$35.80
1	•	12		•	40-PIN DIP	\$115
1		—	•	•	20-PIN DIP, 20-PIN SO	\$16
1	•	12			24-PIN DIP	\$25.50
1	•	12			24-PIN DIP	\$12.25
1	•	8 OR 16			40-PIN DIP	\$16.50
1	•	8 OR 13			40-PIN DIP	\$8.95
1	•	8 OR 12			40-PIN DIP	\$29
1	•	8 OR 14			40-PIN DIP, 40-PIN LCC	\$49
1	•	8 OR 12			28-PIN DIP	\$30
1	•	8 OR 12			28-PIN DIP	\$38
1	•	8 OR 12			28-PIN DIP	\$30
1	•	8 OR 12			28-PIN DIP 28-PIN LCC	\$35
1	•	8 OR 12			24-PIN SO, 24-PIN, 0.3-IN. DIP	\$23
1		—	•		8-PIN SO 8-PIN DIP	<\$20
1	•	8 OR 12			24-PIN SO, 24-PIN, 0.3-IN. DIP	\$27
1	•	8 OR 12			40-PIN DIP, 44-PIN PLCC	\$8.95
7	•	4			40-PIN DIP, 44-PIN PLCC	\$11

Table continued on pg 122

ADC is full of offset and drift error sources. Different metals often create small voltages, much as a thermocouple does, that drift with temperature. One way around this problem is to use a Kelvin-sensed reference. This type of reference senses the voltage at the load, and uses that voltage for regulation, thus removing errors between the reference and the ADC. To obtain the greatest benefit from this approach, you should use an ADC that has multiple inputs for the reference, so that the sense from the voltage regulator can connect directly to the ADC chip.

You can get around many temperature-related drift problems by using ratiometric measurements. As long as the sensor and the ADC are using the same reference, the drift of the reference won't matter, because it will cancel out.

Flash techniques will become prevalent

Even though the majority of available ADCs are using successive-approximation or multislope-integration techniques, these conversion methods will soon step aside for the subranging-flash and delta-sigma methods. Flash conversion is by far the fastest conversion technique. A flash converter has a separate comparator for each of the possible digital output values. The input voltage is fed to all of the comparators. Comparators whose reference is below the input will all generate ones; those that have a reference above the input will all generate zeros. The output of all of the comparators goes to an encoder, which converts the data to a binary value.

The limitation of this approach is the number of comparators required—a 12-bit converter would require 4095 comparators. To achieve the higher ADC resolutions, therefore, ADC manufacturers either use more than one internal flash converter or use the same converter more than once; this technique is called "subranging."

Crystal Semiconductor takes the latter approach in its CSZ5412, a 12-bit, 1-MHz subranging ADC (Ref 4). It uses a 2-step technique: First, it samples the input into an S/H amplifier; then, once the input is held, the 6-bit flash ADC converts the six most significant bits of the digital output and latches them. These six bits are also loaded into the 6-bit DAC. The DAC's output is then subtracted from the input held in the S/H amplifier. The result of this subtraction is the remainder of the original input. The CSZ5412 includes a differential amplifier that multiplies this voltage by 64 to raise it to a value that the 6-bit ADC can convert. The six least

Vendors can already put a complete data-acquisition system on a hybrid device; before long, they'll fit the same circuitry on a monolithic chip.

REPRESENTATIVE MONOLITHIC HIGH-RESOLUTION A/D CONVERTERS (Continued)

MANUFACTURER AND MODEL	RESOLUTION (BITS)	THROUGHPUT/ CONVERSION TIME	INPUT-VOLTAGE RANGE	POWER SUPPLY (V)	POWER DISSIPATION (mW)	INTERNAL REFERENCE	S/H AMPLIFIER
MICRO LINEAR							
ML2200	12 PLUS SIGN	31.7 kHz	± 2.5	± 5	400 MAX	•	•
ML2208	12 PLUS SIGN	31.7 kHz	± 2.5	± 5	400 MAX	•	•
ML2230	12 PLUS SIGN	31.7 kHz	± 2.5	± 5	400 MAX		•
ML2233	12 PLUS SIGN	31.7 kHz	± 2.5	± 5	400 MAX		•
MICRO POWER SYSTEMS							
MP7550	13	40 mSEC	—	± 5 , 12	44 MAX		NA
MOTOROLA							
MC145402	13	213 kHz (ADC ONLY)	± 3.2	$\pm 5V$	50 TYP	•	•
NATIONAL SEMICONDUCTOR							
ADC1205	12 PLUS SIGN	100 μ SEC	0 TO 5 OR ± 5	5 OR ± 5	25 MAX		
ADC1225	12 PLUS SIGN	100 μ SEC	0 TO 5 OR ± 5	5 OR ± 5	25 MAX		
PRECISION MONOLITHICS INC							
ADC-9012	12	12.5 μ SEC	0 TO 10	5, -12, OR -15	85 MAX		
SIGNETICS							
TDA1534	14	8.5 μ SEC TYP	—	± 5 , -17	640 MAX	•	
TELEDYNE SEMICONDUCTOR							
TSC500A	16 PLUS SIGN	—	± 4.2	± 5	15 MAX		NA
TSC804	12 PLUS SIGN	33 mSEC	± 5	± 5	20 MAX	•	NA
TSC850	15 PLUS SIGN	25 mSEC	± 5	± 5	35 MAX		NA
TEXAS INSTRUMENTS							
TLC32040	14	19.2 kHz	± 1.5 , ± 3 , ± 6	± 5	285 MAX	•	•

NOTES:

- LCC = LEADLESS CHIP CARRIER
- PLCC = PLASTIC LEADED CHIP CARRIER
- SO = SMALL-OUTLINE PACKAGE
- NA = NOT APPLICABLE

significant bits are then loaded into the output latch to form the full 12-bit digital value.

One complete conversion takes 1.3 μ sec. To achieve 1-MHz throughput (1- μ sec conversions), the CSZ5412 pipelines both the sampling process and the conversion process: It initiates the next hold command while the last result is being latched into the output. A second S/H amplifier also pipelines the acquisition of a sample by holding the input while the 6-bit ADC determines the remainder.

The CSZ5412 uses self-calibration to ensure 12-bit accuracy. An internal microcontroller performs the

calibration; it maintains the 64 graduated reference levels, the gain, and the offset of the 6-bit flash ADC, and the gain and offset of the differential amplifier.

Subranging-flash techniques will be increasingly important in future ADCs. Speakers at this year's ISSCC discussed many such pipelined ADC designs that promise to realize high speed and high resolution. Analog Devices, for example, will soon be coming out with a 12-bit ADC that has 200-kHz throughput and a 14-bit, 10- μ sec ADC, both of which use variations of the subranging-flash technique.

The other important conversion technique is the

INPUT CHANNELS	PARALLEL I/O	WORD WIDTH	SERIAL I/O	SELF-CALIBRATION	PACKAGE	PRICE (100)
4	•	8		•	40-PIN DIP	\$41
8	•	8		•	40-PIN DIP	\$43
1	•	8		•	24-PIN DIP 28-PIN PLCC	\$15.95
1	•	13		•	28-PIN DIP 28-PIN PLCC	\$15.95
1	•	8 OR 13			40-PIN DIP	\$26
1		—	•		16-PIN DIP 16-PIN SO	\$7.67 (1000)
1	•	8			24-PIN DIP	\$19.95
1	•	12			28-PIN DIP	\$19.95
1	•	8 OR 12			24-PIN 0.3-IN. DIP 24-PIN SO	\$24.95
1		—	•		28-PIN	\$12
1	—	—	—	—	16-PIN DIP, 16-PIN SO	\$8.95
8	•	8 OR 13			68-PIN PLCC	\$10.95
1	•	8			40-PIN DIP	\$20 TO \$25
2		—	•		28-PIN DIP	\$26

delta-sigma method. The delta-sigma technique uses oversampling and digital filtering to achieve high resolution. A delta-sigma ADC consists of an analog modulator and a digital filter. The modulator's output provides a single-bit result at a very high rate that the digital filter can process into a high-resolution output at a lower rate.

The advantage of using delta-sigma conversion is mostly a reduction in cost, both of the converter and, in some applications, of the system. One delta-sigma ADC, the Crystal Semiconductor CS5501, is mostly digital; the analog circuitry consumes only the lower

fifth of the device. The delta-sigma approach yields a device that's more digital than analog, so it's easier and cheaper to produce and will benefit from the shrinking geometries of the future.

Another advantage of the delta-sigma type of converter is that it includes a digital lowpass filter with a cutoff frequency of 0.1 to 10 Hz, so it eliminates common interference caused by ac power sources. Further, the serial output of this converter is ideal for use as input to a serial communication device, allowing the LAN-style connection of sensors. This scheme would facilitate the manufacture of high-resolution digital sensors, perhaps even on single chips.

A disadvantage of using the delta-sigma converter is that you'll require one converter for every channel. Because the digital filter contains historical data, you can't multiplex the input. Also, the filter's parameters are preset and may not fit your application. When evaluating these converters, consider the cost of getting the signals from the sensor to the multiplexed ADC. Serial digital cables are much less expensive than many analog cables, and digital transmission, by its nature, offers a number of advantages over analog transmission.

The Crystal CS5501 is a 16-bit delta-sigma converter with a bandwidth of 0.1 to 10 Hz, depending upon the clock rate. Also dependent upon the clock rate is the output-update rate, which is the rate at which the data is clocked out of the ADC. The CS5501's output-update rate varies from 40 Hz to 4 kHz. The company intends the ADC for use with low-frequency signals in such applications as scales and dc measurements.

The CS5501 includes self-calibration circuitry for system calibration. You could use the CS5501 in a data-acquisition system, for example (Fig 1). The calibration circuitry, along with an external multiplexer, will compensate for the gain and offset of the entire system.

In the near future, you can expect to see many more delta-sigma converters on the market. Crystal expects to have an 18-bit version of the CS5501 out before the end of the year; that chip will be pin compatible with the 16-bit version.

ADC manufacturers have also begun to include self-calibration circuitry on their monolithic ADCs. The most important advantage of self-calibration is that it lets you calibrate the device at any time. Self-calibration circuitry will appear in all types of converters over the next few years.

Micro Linear's ML2200 ADC family, for example,

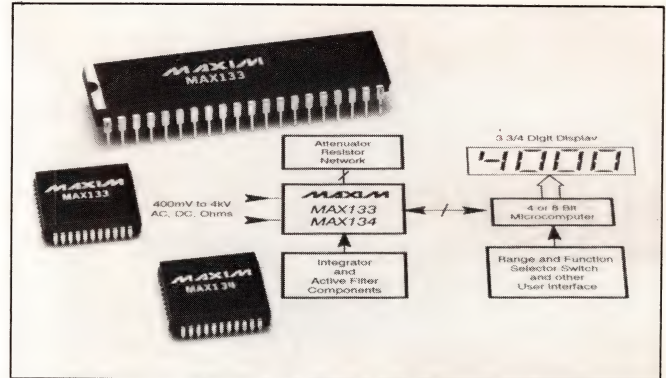
Consumer digital audio equipment will help drive the price of 16-bit ADCs below that of today's 12-bit ADCs, thus forcing the 12-bit ADCs below \$10.

includes self-calibration (Ref 5). The parts' conversion algorithm is a version of successive approximation; the devices, which Micro Linear calls "algorithmic ADCs," have two distinct advantages: They require compensation only for the internal offsets and the times-2 multiplier, and, compared with other types of converters, they have fewer components that require adjustment. The offsets of both the S/H amplifier and the times-2 amplifier are nulled before each conversion. The gain of the times-2 amplifier is determined by the ratio of two capacitors. During calibration, the chip sets the gain by automatically adjusting the capacitor ratio with one fixed capacitor and one variable capacitor. The variable capacitor comprises a selection of smaller capacitors.

GE Solid State's ICL7112 and ICL7114 ADCs use a self-calibration scheme that employs a one-time-programmable (OTP) ROM to store the calibration values. The ICL7112 is a 12-bit, 40- μ sec converter; the ICL7114 produces a 14-bit result in the same 40 μ sec.

Crystal Semiconductor also offers a line of self-calibrating ADCs: The CS5012, CS5014, and CS5016 are 12-, 14-, and 16-bit converters, respectively. They all use the popular successive-approximation technique. Instead of comprising the traditional resistor network, the DAC is an array of binary-weighted capacitors.

To achieve 16-bit accuracy, the ADC's comparator and DAC must both be very accurate. The comparator's offset is measured during the track mode and subtracted from the input when the conversion begins, so the offset is nulled. The DAC consists of a number of binary-weighted capacitors. Each of these capacitors,



Adding some external passive components to the Maxim MAX133 integrating ADC is all you have to do to provide the converter with a voltage divider that has a software-selectable range of ± 400 mV to ± 4000 V. The converter performs integrating A/D conversion by using a $\pm 40,000$ -count residual-multiplication technique.

in turn, is made up of many small capacitors. The automatic-calibration feature maintains the DAC's accuracy by selecting the capacitors to adjust the overall bit weight.

Just because an ADC supplies self-calibration circuitry doesn't mean that the device will drift away from its specifications quickly—it just means you have the opportunity to make corrections whenever necessary. The ADCs from Crystal, for example, maintain their accuracy over time and temperature, and also perform self-calibration every time you apply power. They don't have an on-chip reference, however, so you may have to recalibrate for variations in the external reference you use.

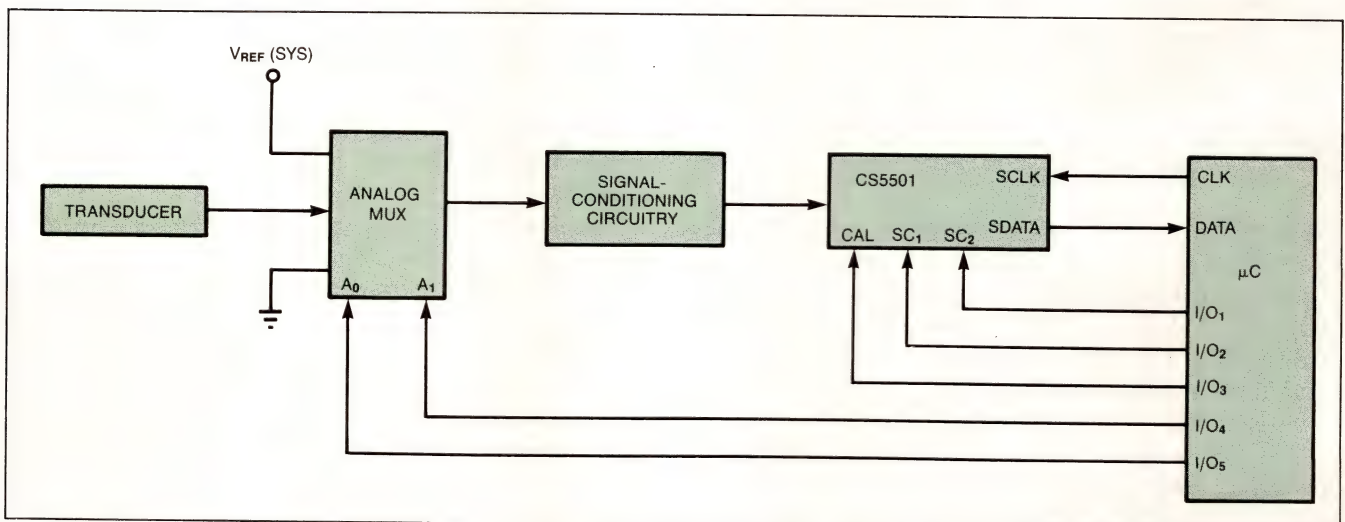
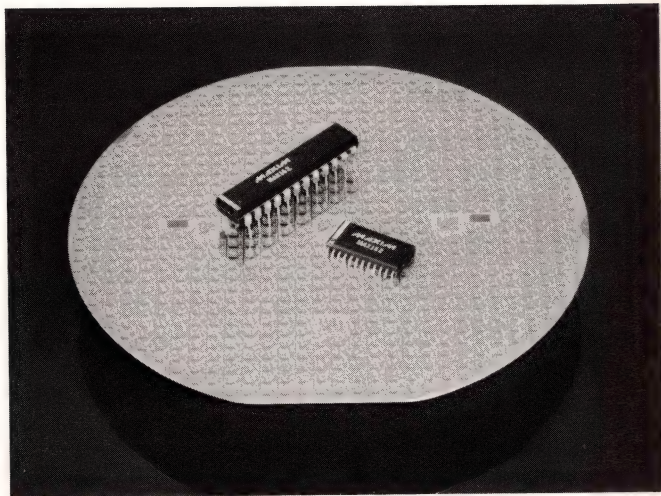


Fig 1—The ability to perform system self-calibration, as the Crystal Semiconductor CS5501 does, allows you to compensate for the gain and offset errors of all of the system components. The CS5501 compensates for these errors by adjusting itself to counteract them.



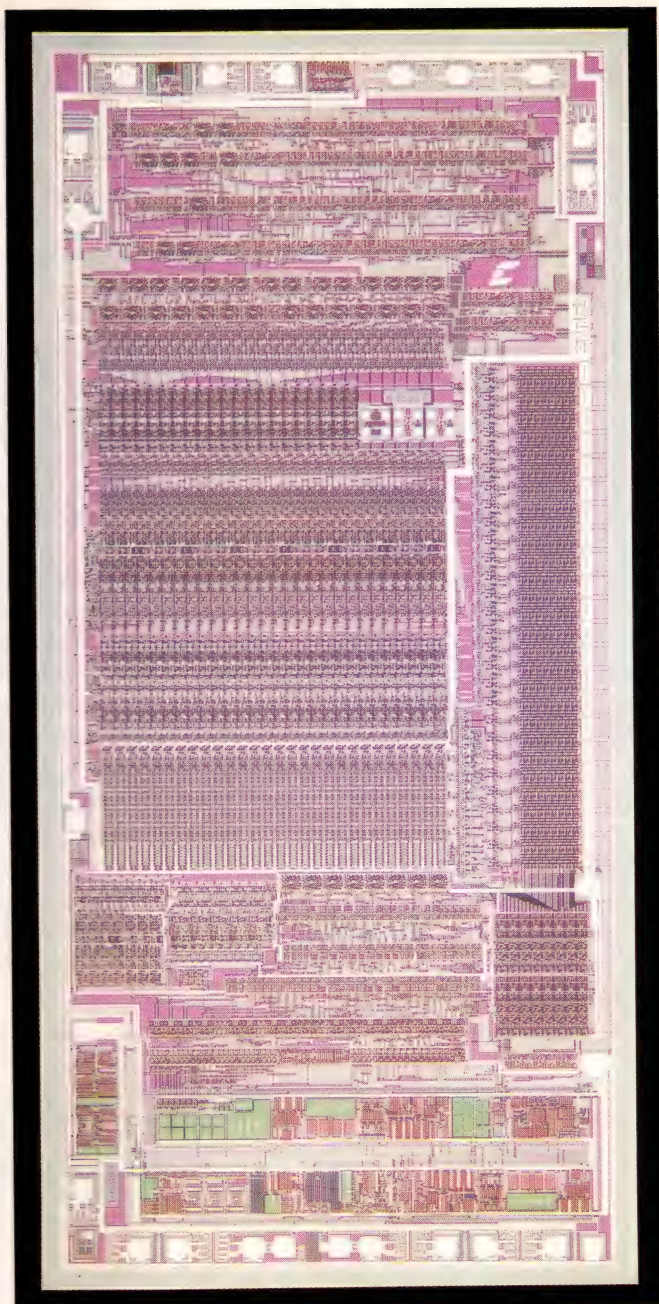
This 12-bit, monolithic ADC (the MAX162 from Maxim Integrated Products) unites high speed with low cost: It offers a 3- μ sec conversion time and costs \$23 (100).

Most other ADC manufacturers will soon produce self-calibrating ADCs, either one-time-programmable ones, such as those from GE Solid State, or ones that calibrate on command, as do those from Crystal and Micro Linear.

12-bit jellybean ADCs

The market is about to see a major price reduction in 12-bit ADCs, which are becoming commodity parts. Competition is fierce among the many companies that produce these parts: Even the price of high-speed (3- μ sec) converters is down near \$20. Remaining competitive in a commodity market usually means providing something that your competition doesn't. The range of 12-bit ADCs, therefore, includes a lot of niche parts that are expressly intended for particular applications.

Complete analog interfaces are also beginning to arrive in the marketplace. Texas Instruments' TLC32040 comes in a 28-pin package that contains a 2-channel input multiplexer, a programmable input filter, a 14-bit ADC with an S/H amplifier, a 14-bit DAC, a programmable output filter, a voltage reference, a serial interface, and a clock with a programmable sample rate (Fig 2). The TLC32040 interfaces directly to the TMS320 family of digital-signal processors and handles the interface to your sensors. You can program the corner frequency of the switched-capacitor filters by using an internal divider and selecting the master clock frequency. The input bandpass filter is intended for telecomm applications; you can bypass it if it doesn't meet your needs.



Even though its die photo looks entirely digital, the CS5501 from Crystal Semiconductor is a 16-bit A/D converter. The only analog circuitry resides on the lower fifth of the chip—the rest of the chip comprises an FIR filter, an IIR filter, some control circuitry, and a serial interface. The chip uses the delta-sigma conversion technique for signals from dc to 10 Hz.

Another ADC that includes an output DAC on chip is the Motorola MC145402. This 13-bit ADC/DAC has an S/H amplifier, a voltage reference, and a serial interface. The ADC uses the same DAC that the output uses. To permit both input and output operations, the output has an S/H amplifier that can hold any value sent to the DAC while the DAC is being used in the A/D conversion. When the device is being used for both input and output, its maximum throughput rate is 16 kHz. When the part is being used for just A/D conversion, its maximum throughput rate is 21.3 kHz.

The Micro Linear ML2200/08 12-bit-plus-sign ADC is not necessarily easier to use, but it eases the burden on

Converters with 16-bit resolution are useful in DSP applications, which don't require absolute accuracy—it's the ADCs' dynamic specs that are important.

your system software because it includes many digital functions on chip. It contains a programmable sequencer, a double 8-word buffer, limit alarms, a 16-bit counter, and a μ P interface. Because these functions are on chip, the ADC can perform many operations that would be time consuming to perform in software.

Note also that many μ P and DSP chips have built-in serial interfaces, which are ideal for data acquisition. Most parallel-output ADCs can't keep up with the high-speed cycle times of DSP chips. Even when the DSP chip is using wait states, the ADC's 3-state output must relinquish the bus quickly. If it can't, you may need to use a 3-state buffer. ADCs that have built-in serial interfaces can easily interface to DSP chips that have built-in serial interfaces. To meet this need, ADC manufacturers are beginning to include serial interfaces on their ADC chips. The MAX170 from Maxim Integrated Products, for example, is a 12-bit, 5- μ sec ADC with a serial output that comes in an 8-pin package.

Burr-Brown's ADC80 and most of Crystal Semiconductor's converters have both parallel and serial outputs.

Serial I/O helps solve problems

A further advantage of the serial interface is that it lets you easily isolate the digital system from the ADC. The digital section contains many sources of noise that get back into the analog signal and affect the accuracy of the conversion. Isolating the digital section from the analog section can help reduce this noise. It's much easier to isolate a serial interface than it is to isolate a 12- or 16-bit parallel bus. Maxim will soon introduce the MAX171, a serial ADC (based on the MAX170) that has an optoisolated output.

Integrating ADCs are still going strong

The activity in other areas of the ADC market has recently obscured the humble integrating ADC, but that type of converter is still selling well. Even the ancient 7109 12-bit integrating ADC is still going

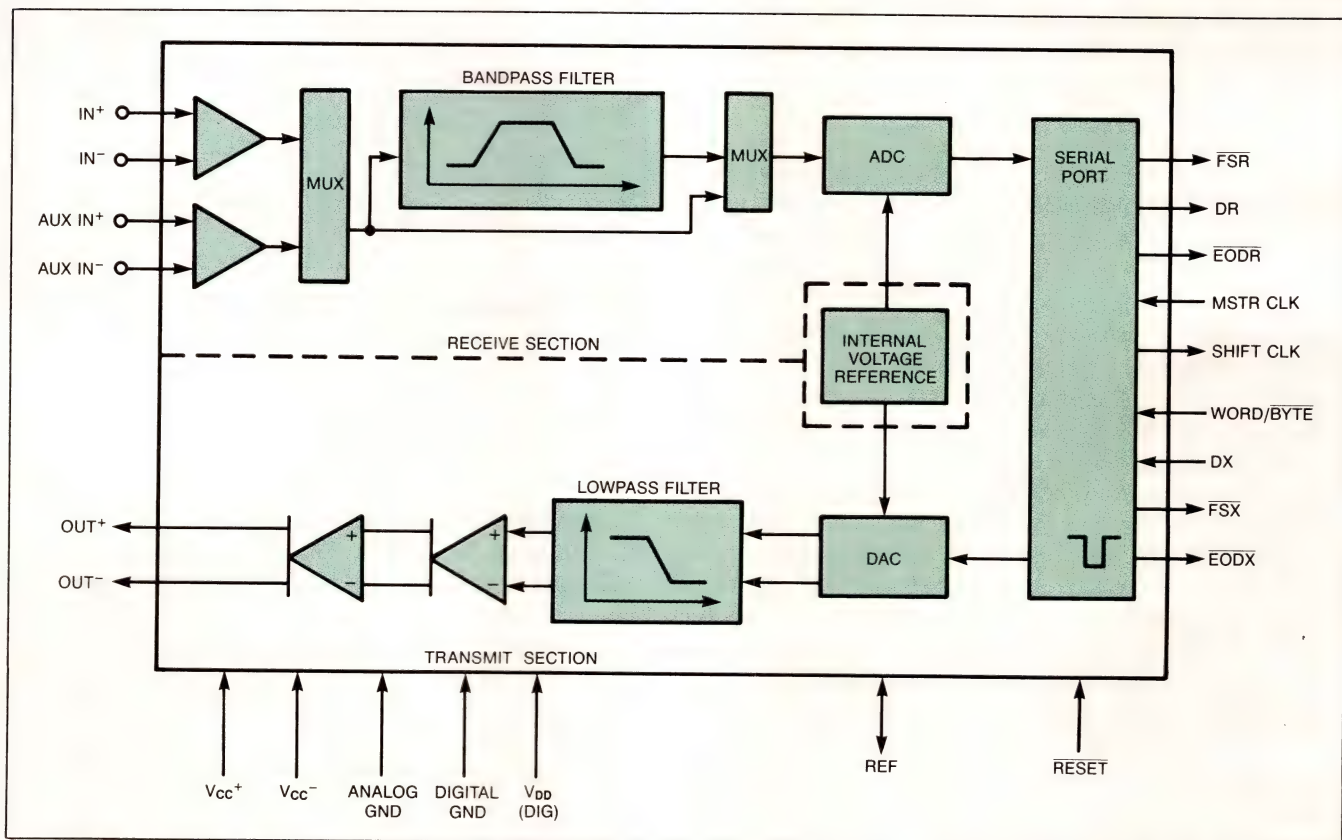
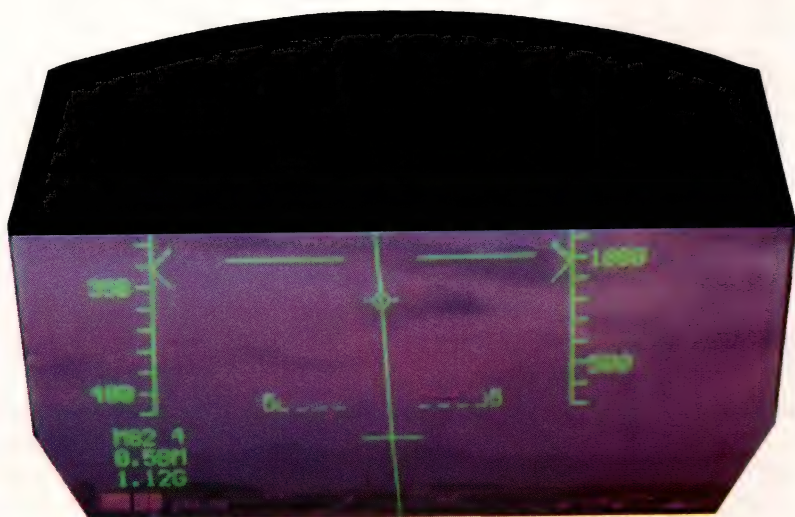


Fig 2—An example of the continuing trend toward placing more functions on a single chip is the Texas Instruments TLC32040 Analog Interface Chip. This single chip contains a 2-channel input multiplexer, a programmable input filter, a 14-bit ADC with an S/H amplifier, a 14-bit DAC, a programmable output filter, a voltage reference, a serial interface, and a clock with a programmable sample rate.

IF YOU'RE NOT CONSIDERING OUR OP AMPS, YOU'RE NOT GETTING THE WHOLE PICTURE.



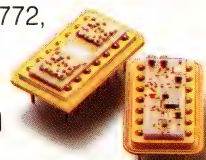
Teledyne Philbrick op amps. The front-runners for speed and accuracy.

Fast settling over a wide bandwidth is the essence of high-performance op amps in sophisticated, high-speed data acquisition, microwave transmission and video/CRT applications. So it pays to specify the best: the 1467 and 1493 operational amplifiers from Teledyne Philbrick.

These Teledyne Philbrick designs are specially engineered to maximize DC characteristics and high-speed performance. The 1467, 1GHz gain-bandwidth op amp ensures 70ns settling times to $\pm 0.01\%$ FS while providing ultra-low input offset voltage of $\pm 30\mu\text{V}$ and input offset voltage drift of $\pm 1\mu\text{V}/^\circ\text{C}$.

The 1493, a dual 350MHz gain-bandwidth op amp, features individual compensation and offset adjustments, FET inputs, 180ns settling times to $\pm 0.01\%$ FS and 80dB isolation at 100KHz.

Qualified to MIL-STD-1772, Teledyne Philbrick is a leading manufacturer of high-performance, high-reliability standard and custom microcircuits for industrial, medical, military and space applications worldwide. Send for complete specifications or call us toll-free at 1-800-325-1330 (outside MA).



MIL-STD-1772 Qualified

TELEDYNE PHILBRICK

40 Allied Drive, Dedham, MA 02026-9103, Tel: 617-329-1600 Fax: 617-326-6313

WEST:
30423 Canwood St.,
Suite 212
Agoura Hills
CA 91301
Tel: (818) 889-3827
Fax: 818-889-8215

U.K.:
The Harlequin Centre
Southall Lane
Southall
Middlesex
UB2, 5NH, U.K.
Tel: 571-9596
Telex: 935008
Fax: 571-9442

JAPAN:
4th Floor
Taiko No. 3 Bldg.
2-10-7 Shibuya-Ku
Tokyo 542, Japan
Tel: 797-5251
Telex: 781-24335
Fax: 797 5255

The subranging-flash conversion method will greatly increase ADC speed; delta-sigma conversion techniques will lead to much higher resolution.

strong. Hybrid integrating ADCs have reached 22-bit resolution, so you can expect to see an ongoing increase in the resolution of monolithic integrating converters.

Integrating ADCs usually cost less than \$12 (100), and designers will continue to use them in low-frequency and dc-measurement applications. One of the major advantages of integrating ADCs is that by selecting the appropriate integration time, you can eliminate much of the ever-present 60-Hz interference.

The TSC500A from Teledyne Semiconductor is an integrating ADC building block that contains all the analog circuits you need to construct an integrating, dual-slope ADC. Your system μ P performs the digital functions. You can implement an ADC with any resolution—as high as 16 bits plus sign—by changing the software. The manufacturer offers an evaluation kit that includes IBM PC-based software.

The TSC804 is useful for measuring more than a single input. The device is a 12-bit integrating ADC that's similar to the 7109 and that has an 8-channel (4-channel differential) multiplexer on the input.

The Maxim MAX133 integrating ADC also allows multiple inputs—it accepts as many as seven. The

manufacturer intended the multiplexer for automatic range selection in DMM applications. You add external resistors to create a voltage divider that has a software-selectable range of ± 400 mV to ± 4000 V. The converter performs integrating A/D conversion by using a $\pm 40,000$ -count residual-multiplication technique. During normal use of the ADC, you ignore the least significant digit. For high-resolution applications, you can read all the digits and average them over a number of readings (usually 10) to achieve full accuracy.

By using a 2-step conversion process, the Teledyne TSC850 converts a signal 16 times faster than does the TSC800, allowing 40 conversions/sec. This approach converts the nine MSBs quickly and then uses a slower, more precise conversion to resolve the six LSBs.

Over the next few years, monolithic ADCs will make quantum leaps in speed and resolution. High-end ADCs—ones having resolutions of 16 bits and higher—will continue to develop as they have in the past: ADCs that exist as board-level products today will become modules, then hybrids, and finally monolithic ICs.

Remember, however, that merely using a very accurate converter in a system won't guarantee that your

Manufacturers of monolithic high-resolution ADCs

For more information on high-resolution ADCs such as those discussed in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Analog Devices Inc
Box 9106
Norwood, MA 02062
(617) 329-4700
TLX 924491
Circle No 650

Burr-Brown
Box 11400
Tucson, AZ 85734
(602) 746-1111
TLX 666491
Circle No 651

Crystal Semiconductor Corp
4210 S Industrial Rd
Austin, TX 78744
(512) 445-7222
TWX 910-874-1352
Circle No 652

Datel Inc
11 Cabot Blvd
Mansfield, MA 02048
(617) 339-3000
TLX 951340
Circle No 653

GE Solid State
10600 Ridgeview Ct
Cupertino, CA 95014
(408) 996-5000
Circle No 654

Honeywell Inc
1150 E Cheyenne Mountain Blvd
Colorado Springs, CO 80906
(303) 577-1000
TLX 452433
Circle No 655

Hybrid Systems Div
22 Linnell Circle
Billerica, MA 01821
(617) 667-8310
Circle No 656

Maxim Integrated Products
120 San Gabriel Dr
Sunnyvale, CA 94086
(408) 737-7600
TWX 910-350-4114
Circle No 657

Micro Linear
2092 Concourse Dr
San Jose, CA 95131
(408) 433-5200 ext 412
TLX 275906
Circle No 658

Micro Power Systems
3151 Jay St
Santa Clara, CA 95054
(408) 727-5350
TWX 910-338-0154
Circle No 659

Motorola Semiconductor
3501 Ed Bluestein Blvd
Austin, TX 78721
(512) 928-6880
Circle No 660

National Semiconductor
2900 Semiconductor Dr
Santa Clara, CA 95052
(408) 721-6230
Circle No 661

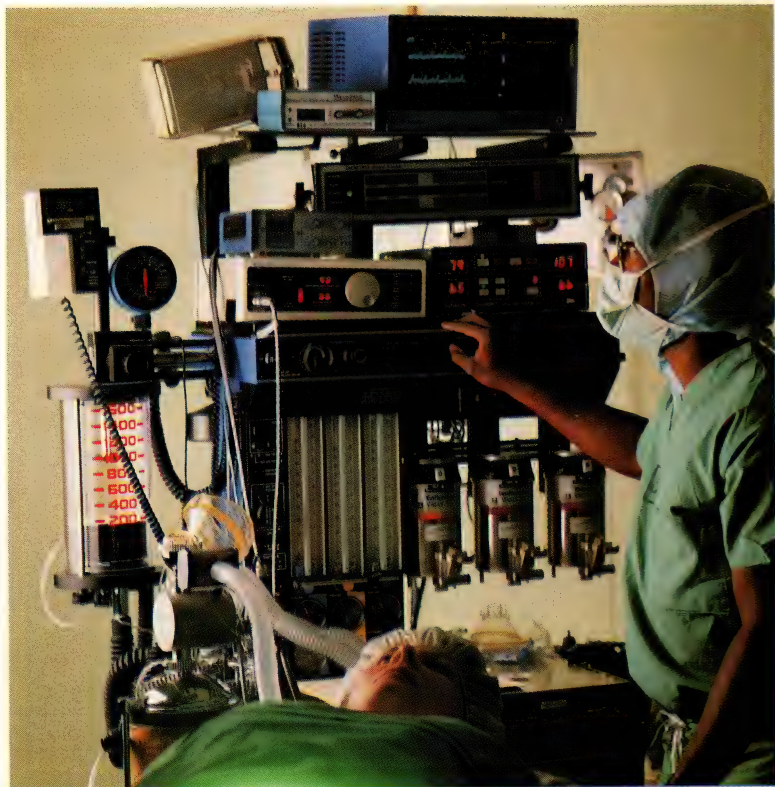
Precision Monolithics Inc
1500 Space Park Dr
Santa Clara, CA 95054
(408) 727-9222
Circle No 662

Signetics Corp
811 E Arques Ave
Sunnyvale, CA 94088
(408) 991-2000
Circle No 663

Teledyne Semiconductor
1300 Terra Bella Ave
Mountain View, CA 94039
(415) 968-9241
TWX 910-379-6494
Circle No 664

Texas Instruments Semiconductor Group
Box 809066
Dallas, TX 75380
1-800-232-3200, ext 700
Circle No 665

WHEN IT'S CRITICAL, OUR A/D CONVERTERS MAKE A DIFFERENCE.

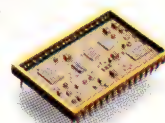


The 4192 and 4193/95 500ns A/D converters from Teledyne Philbrick: the fastest speed for the most demanding applications.

Whether your device monitors a patient or measures electron spin in EMR, nanoseconds can make the difference. That's why, for any critical application, you should specify Teledyne Philbrick—for the fastest A/D converters in the industry.

Available in two standard configurations, the 4192, 4193 and 4195 12-bit converters feature 500ns conversion time, power consumption as low as 1.7W and tri-state output buffers for bus interfacing.

The 4192 converter lets you select from three input ranges: 0 to +10V, $\pm 10V$ and 0 to +20V. Factory laser trims adjust all parameters, eliminating the need for external circuitry. Sampling dynamic signals at better than 1.3MSPS can be achieved by combining these devices with the 4860 Track-Hold amplifier.



Specifically designed for fast, precise digitizing of analog signals, these devices also feature low harmonic distortion and excellent signal-to-noise ratio.

Qualified to MIL-STD-1772, Teledyne Philbrick is a leading manufacturer of high-performance, high-reliability standard and custom microcircuits for industrial, medical, military and space applications worldwide. Send for complete specifications. Or call us toll-free at 1-800-325-1330 (outside MA).

MIL-STD-1772 Qualified

TELEDYNE PHILBRICK

40 Allied Drive, Dedham, MA 02026-9103, Tel: 617-329-1600 Fax: 617-326-6313

WEST:

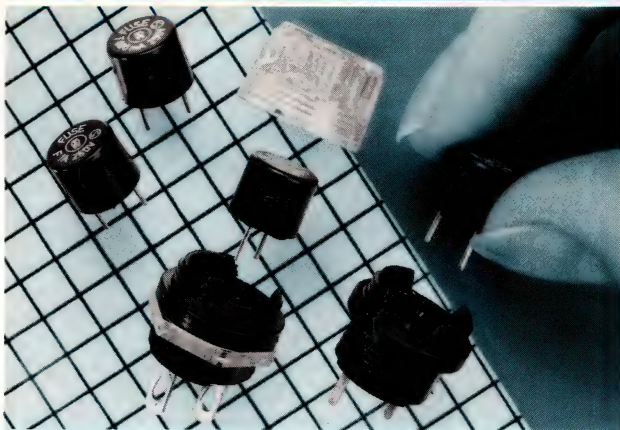
30423 Canwood St.,
Suite 212
Agoura Hills
CA 91301
Tel: (818) 889-3827
Fax: 818-889-8215

U.K.:

The Harlequin Centre
Southall Lane
Southall
Middlesex
UB2, 5NH, U.K.
Tel: 571-9596
Telex: 935008
Fax: 571-9442

JAPAN:

4th Floor
Taiko No. 3 Bldg.
2-10-7 Shibuya-Ku
Tokyo 542, Japan
Tel: 797-5251
Telex: 781-24335
Fax: 797-5255



A new idea for safe equipment protection

Shock-safe subminiature fuse-holders for TR 5 fuses

WICKMANN's newly designed fuse-holder range for internationally standardized and approved subminiature fuses, type TR 5, is available in two versions:

- front panel mounting with solder or plug in terminations
 - printed-circuit board mounting with solder pins
- Meeting established fuseholder standards, 5 x 20 mm performance is now available in a fraction of the size. Yet another example of WICKMANN innovation.



A mark of safety

Wickmann-Werke GmbH

Annenstr. 113 · Postbox 2520 · D-5810 Witten 6
Tel. 02302/6620 · Telex 8229145wwg d · Fax 02302/662111

CIRCLE NO 14

80C31/51

Microcontrollers A wide range in record time

- ✓ A choice between 4, 8 or 16 Kbytes of ROM, with on-chip RAM from 128 to 256 bytes, all CMOS.
- ✓ Operating clock speeds range from zero up to 16 and even 18 MHz!
- ✓ The MHS "Quick ROM" service can have customized samples or production parts delivered to your doorstep in just two or three weeks.
- ✓ And for ROMless 80C31/C32 parts, delivery worldwide is virtually instantaneous.

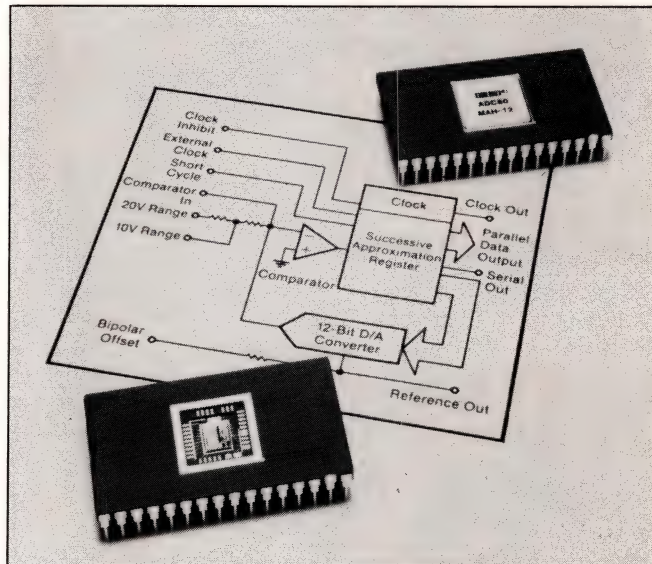
With over 7 million units delivered to date, MHS is one of the world's leading – and fastest – microcontroller suppliers.



Ask for a quotation today:

MATRA DESIGN SEMICONDUCTOR
2895 Northwestern Parkway
SANTA CLARA, CA 95015,
USA.
Tel. 408-986 9000, Tx. 299656

MATRA HARRIS SEMICONDUCTEURS
BP 309
78054 SAINT-QUENTIN-YVELINES CEDEX
FRANCE.
Tel. 1-30 60 70 00, Tx. 697 317



The hybrid ADCs of yesterday are monolithic devices today. The monolithic ADC80MAH-12 from Burr-Brown, for example, was a hybrid that the company originally introduced about 10 years ago.

system's measurements will also be accurate. As you begin to design with ADCs that have resolutions higher than 16 bits, your design abilities will have to improve. Each time you design with a high-resolution ADC, you can learn a little more about optimizing a design to take advantage of the ADC's capabilities. When the 22-bit ADCs that now exist in hybrid form become monolithic and their prices drop to an affordable level, you'll have to be well versed in high-precision analog-design techniques in order to take advantage of them. **EDN**

References

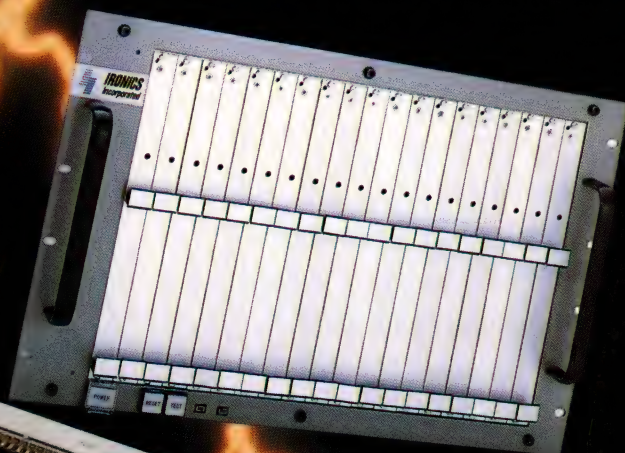
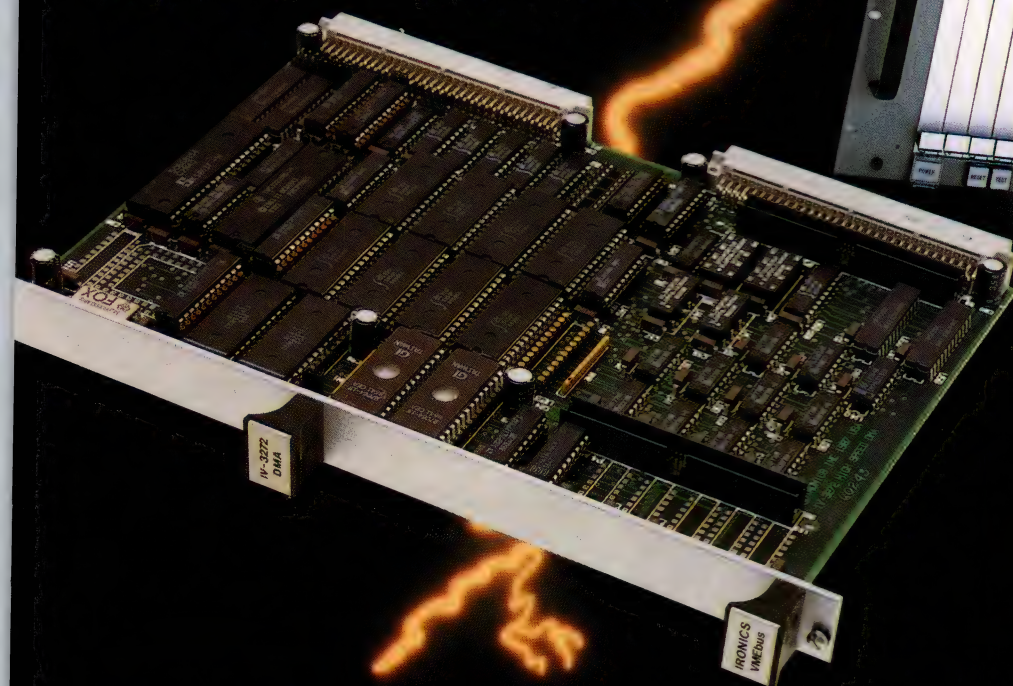
1. Coleman, Brendan, et al, "Coherent sampling helps when specifying DSP A/D converters," *EDN*, October 15, 1987, pg 145.
2. Little, Al, and Bob Burnett, "S/H amp-ADC matrimony provides accurate sampling," *EDN*, February 4, 1988, pg 153.
3. Knapp, Ron, "Selection criteria assist in choice of optimum reference," *EDN*, February 18, 1988, pg 183.
4. Mosley, J D, "Monolithic A/D converter delivers 1-MHz, 12-bit performance at low cost," *EDN*, February 18, 1988, pg 128.
5. Fleming, Tarlton, "Monolithic, self-calibrating ADC includes sample-and-hold amplifier," *EDN*, January 21, 1988, pg 87.

Article Interest Quotient (Circle One)
High 491 Medium 492 Low 493



IRONICS - THE REAL-TIME MULTIPROCESSING COMPANY

**THE LIGHTNING
FAST
CONNECTION
TO THE
REAL-TIME WORLD...**



**NOW
FASTEST WHEN
USED WITH IRONICS
MULTIPROCESSING
ENGINES!**

IV-3272 VMEbus FULL SPEED DATA TRANSPORTER

- **CONNECT HIGH DATA RATE APPLICATIONS TO VMEbus**
40 Mbytes/sec gateway to the real-time world via standard and custom Daughter Boards
- **INTERCONNECT VMEbus BACKPLANES VIA SMALL AREA NETWORK**
Parallel I/O Daughter Board allows 40 Mbytes/sec chassis to chassis transfers, with protocol.
- **CUSTOMIZE INTERFACES TO YOUR OWN REQUIREMENTS**
Well defined specification simplifies design of your own Daughter Boards. For example, a 12.5 Mbytes/sec Fiber Optic Link
- **ADD MORE DATA TRANSFER INTENSIVE MULTIPROCESSING SUBSYSTEMS**
32.8 Mbytes/sec (writes) dual-port transfer rate achievable using Ironics' Multiprocessing Engines™ with Static Column Block Transfer™ (SCBLT) Capability
- **PROCESS DATA 'ON THE FLY' WITH ON-BOARD DIGITAL SIGNAL PROCESSOR**
TI 32010,020 or C-25 DSP Chip is user-programmable

For further information on the unique IV-3272 FSDT or on any of IRONICS' Real-Time Multiprocessing Products, call or write for The Ironics' Real-Time Multiprocessing Data Pack. Ironics Incorporated, 798 Cascadilla Street, Ithaca, NY 14850. Telephone (607) 277-4060 Telex 705-742, FAX 607-272-5787.

CIRCLE NO 82



**IRONICS
Incorporated**

INTRODUCING THE IDEAL



A leader's work is never done.

No sooner do we invent the Programmable Gate™ Array and with it a whole new category of logic devices, than we're already outdoing ourselves.

By adding a brand new, more powerful family of Programmable Gate Arrays, the 3000 series.

What's new and different?

They're faster and denser,

Xilinx Programmable Gate Arrays have densities up to and including 9000 honest gates. How dense can you get? We aim to keep finding out.

with more gates than anybody ever thought a programmable logic device would ever have.

And, are you ready? Cheaper to use than conventional gate arrays.

Which makes them more ideal than ever.

THE PROGRAMMABLE GATE ARRAY, IMPROVED.

The 3000 series has a second generation Logic Cell™ Array architecture that turns a 40 MHz system clock rate.

That's enough speed to run with the highest performance microprocessors you can name.

Of course, our patented



Are the zebra's stripes white-on-black or black-on-white? Should you buy the Programmable Gate Array for its cost-effectiveness, short development cycle, off-the-shelf availability, or its 100% testability? Yes to both questions.

LOGIC DEVICE. AGAIN.

Architecture is also responsible for gate counts that range from 1200 in the XC 2064 to 9000 in the XC 3090.

Enough density for just about any logic application you can name.

Plus more flexibility in routing and gate utilization than you'll know what to do with.

THE ONLY LOGIC DEVICE YOU MAY EVER NEED.

Like all Xilinx Programmable Gate Arrays, our 3000 series offers the same advantages you've come to know and love:

Gate array density.

User-programmability with unlimited reprogrammability.

No NRE or inventory risk.

100% tested parts.

Low cost gate array type design tools.

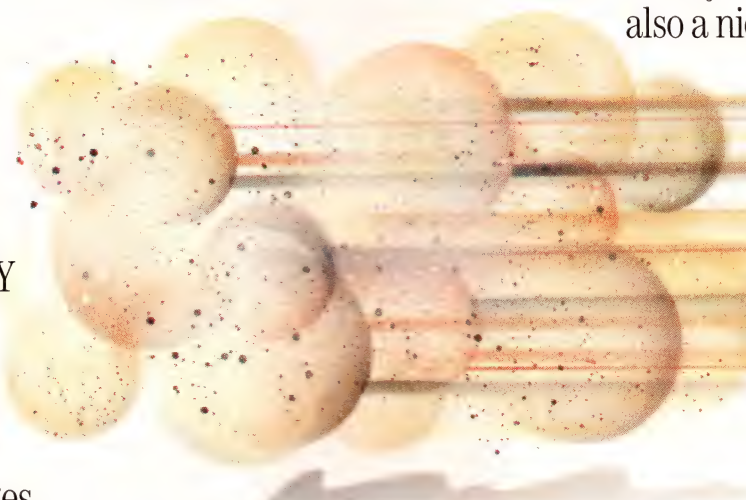
And a development cycle that fits between paychecks.

Our Programmable Gate Arrays also make it simple to choose a logic device.

They simply make every other logic device obsolete.

With their new architecture, you'll have the speed you need, plus the density to get all your logic on one device.

A device with advantages no other technology can match.



Want to see how fast our new 3000 series is? Want to see it again?

Now stop and ask yourself, "Why should I use anything else?"

Good question, isn't it?

THE PRICE IS RIGHT, TOO.

We've told you about our improved speed.

And our increased density.

But we've saved the best news for last.

Using a Xilinx Programmable Gate Array costs less than using a conventional gate array.

So much less it isn't even funny. At least, not to them.

We can prove it, too.

We've prepared a study that lays out the cost comparison data in detail and, needless to say, we'd love to send you a copy. (There's also a nice thick data

book for those of you who are already true believers.)

Just call us toll-free at (800) 255-7778.

In California, (408) 559-7778. Or contact your local Xilinx sales representative or distributor.

The Programmable Gate Array from Xilinx. It's everything you've ever wanted. Again.



The Programmable Gate Array CompanySM

Xilinx, Logic Cell Array, XACT and Programmable Gate are trademarks and The Programmable Gate Array Company is a service mark of Xilinx, Inc.

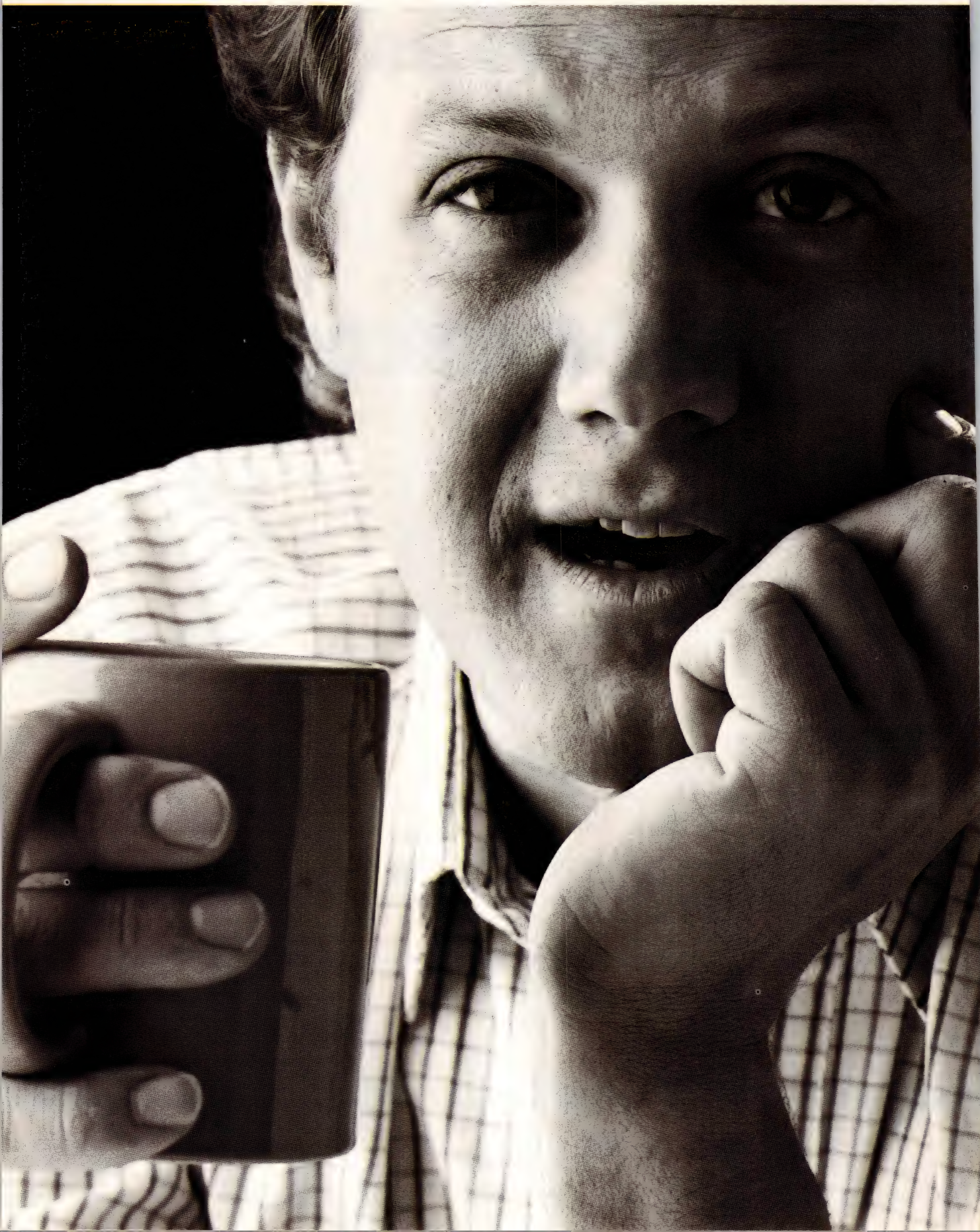
© 1987 Xilinx, Inc., 2069 Hamilton Ave., San Jose, CA 95125, (408) 559-7778.

0.000000000000000000

[illegible]

135

"I shop the specs



because it's my job. But I buy the product because it's my career."

WHAT YOU SHOULD KNOW ABOUT THE NEW PRODRIVE™ SERIES OF 3½-INCH HARD DISK DRIVES FROM QUANTUM.

The numbers are the easy part. Either a product has them or it doesn't.

But you can't build a system out of specs.

You also need dedicated product-support people who will sit down and help you solve some tough engineering problems and put those specs to work.

Quantum is ready to deliver both.

Our new ProDrive Series of 3½-inch hard disk drives offers you the broadest range of capacities in the broadest range of interfaces in the industry. 42 and 84 megabyte formatted with embedded SCSI interface right now. And later this year, up to 168 megabytes, in SCSI, ESDI, and AT-Bus. Ten new drives in all.

All with access times of 19 ms or less.

With synchronous data transfers to the SCSI bus of 4 megabytes per second, and asynchronous data transfers of 2 megabytes per second.

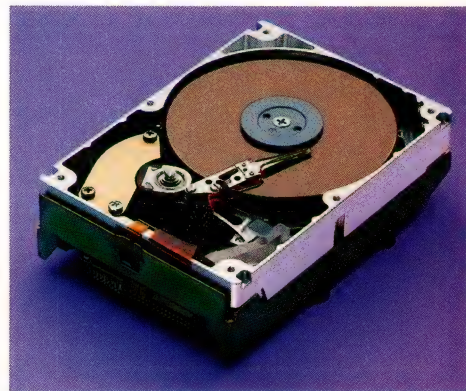
With an MTBF of 50,000 hours.

And with DisCache™, Quantum's unique 64 kilobyte data-buffering scheme that can make our 19-ms drive perform like a 12-ms drive—or even faster, depending on your application.

But Quantum also offers you the people who can help you put those numbers to work in your own system. A dedicated team of engineering professionals who understand the particular needs of the systems designer—and can help meet those needs quickly, efficiently, cost-effectively.

The new ProDrive Series. The specs you want. The support you need.

That's what Quantum delivers.



INTRODUCING THE PRODRIVE SERIES

- 3½-inch form factor
- 42, 84, 103, 120, 145, 168 MBs formatted
- SCSI, ESDI, AT-Bus
- 19 ms or faster average access time
- 64 KB buffer with exclusive DisCache™
- 50,000-hour MTBF
- 42, 84 MB SCSI evaluation units AVAILABLE NOW
- 42, 84 MB AT-Bus units available early summer '88

Quantum

Quantum Corporation
1804 McCarthy Blvd.
Milpitas, CA 95035

ProDrive and DisCache are trademarks of Quantum Corporation.

Data transformation explains the basics of neural networks

Doug Conner, *Regional Editor*

For problems that digital computers can't readily solve, you might soon find that artificial neural networks offer a practical alternative. To obtain an overview of neural networks' capabilities, we developed two simple networks, we simulated them in software, and we built and tested one analog neural-network circuit.

The neural-network approach to data transformation is noteworthy for two reasons. First, neural networks are parallel computing architectures and therefore do not suffer the sequential bottlenecking problems that can occur when a serial processor tries to perform parallel processing. Second, neural networks aren't explicitly programmed with the algorithm that would solve the problem at hand; instead, they must *learn* to solve the problem.

The ability of feedforward neural networks (also called mapping neural networks) to learn a transformation isn't necessarily an advantage. Among the drawbacks are the need for training data sets (from which the networks can learn) and the need for a learning period. Moreover, neural networks are not well suited to problems requiring high accuracy.

Therefore, most problems for which a known algorithm exists are best solved by executing the algorithm on conventional computers. Neural networks can best solve problems for which no algorithm exists or for which the algorithmic solution is too slow.

Our simple example—a neural network that maps an input X to $\sin(X)$ —illustrates the basics of neural

networks. A conventional approach to this problem would involve the use of an approximate mathematical function, such as Taylor's expansion, or the use of a lookup table filled with a series of X and $\sin(X)$ pairs. Of these two approaches, the latter more closely corresponds to a neural-network approach, although significant differences do exist (Fig 1).

With the lookup-table approach, a processor locates the table entries for X that bracket the X input value. Then, the processor interpolates (in the highly likely event that the input isn't identical to an X value in the table) to yield a $\sin(X)$ output. In contrast, a neural network does not perform interpolation. However, before it can convert any X to $\sin(X)$, it must learn to solve such problems. This learning requires a training data set, which could be the same X and $\sin(X)$ values that would go into a lookup table.

No relation to $\sin(X)$

During training, the neural network receives an X input, and a learning algorithm compares the neural network's response with the correct $\sin(X)$ value. The learning algorithm then adjusts weighting factors internal to the network in order to minimize the error between the network's output and the correct response. Note that the learning algorithm has no relation to the $\sin(X)$ function and would be equally useful for enabling the network to learn $\sqrt{X}$ or e^X .

After running through a large number of sample

Because neural networks are parallel computing architectures, they aren't hindered by the bottlenecks that can result when a serial processor attempts parallel processing. Neural networks are best at solving problems for which no algorithm exists or for which an algorithmic solution is too slow.

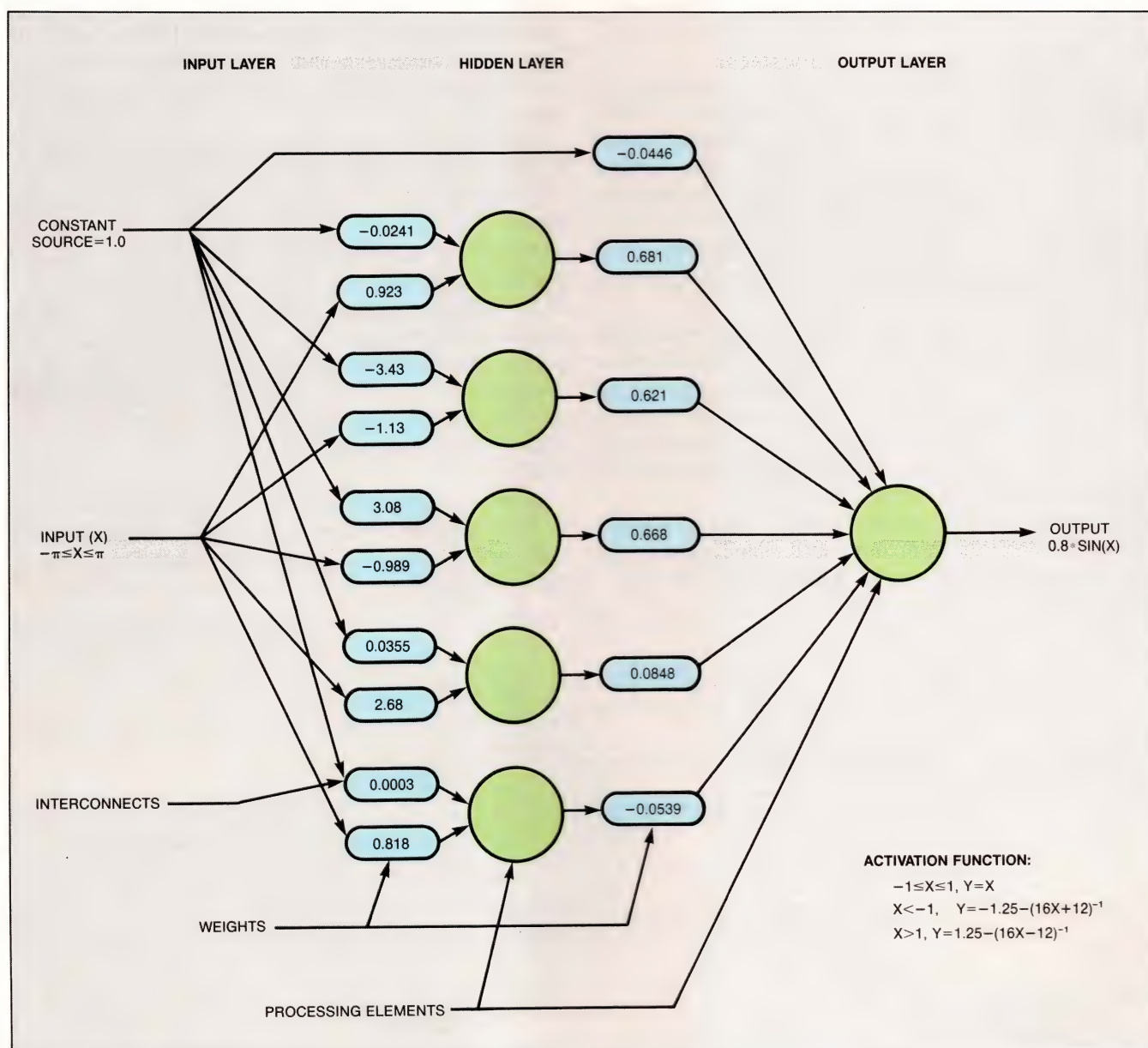


Fig 1—This simple neural network approximates the transformation of X to $\sin(X)$. The network consists of six processing elements and 16 weights.

The term “feedforward” implies that no processing element output can be an input for a processing element on the same layer or a preceding layer.

pairs from the training set, the neural network, which initially was in some random state, will have learned to some extent the X -to- $\sin(X)$ transformation. Once the network has learned the transformation, the learning algorithm is no longer necessary. If the learning algorithm is removed, the network behaves like an analog lookup table: The network receives an input value and generates an output. The ability of the network to learn a transformation is limited by the architecture of the specific network and by the learning algorithm.

Neural-network basics

To understand how neural networks operate, you need to know some details about their design. Fig 1 shows a simple neural network that performs an approximate X -to- $\sin(X)$ transformation. A feedforward neural network typically comprises layers of interconnected processing elements. The term “feedforward” implies that no processing element output can be an input for a processing element on the same layer or a preceding layer.

The input layer typically performs no function other than the buffering of the input signal. The next layer—the hidden layer—gets its name from the fact that its outputs are internal to the neural network. Only one hidden layer is shown in Fig 1, but for complex mappings, additional layers might appear between the hidden layer and the output layer.

The interconnects convey analog values. Signals passing through the interconnects are multiplied by the weights associated with that particular interconnect.

Each processing element sums all its inputs and then performs a nonlinear transfer function on the sum, as shown in Fig 2. This nonlinear transfer function is also known as the activation function of a neural network. The activation function can take a number of different forms. Fig 3 shows some typical ones. To provide an offset term for the activation function, all processing elements receive a constant-source input, as shown in Fig 2.

Because the activation function limits the range of values generated by a processing element, you will typically have to scale the output of a neural network. For example, in Fig 1 the output is scaled between -0.8 and $+0.8$.

Up to this point we have been discussing the details of a nonlearning neural network; all weights are fixed. During learning the learning algorithm modifies the interconnection weights to reduce the error at the output of the neural network. Ref 1 details a standard learning algorithm for feedforward neural networks. The learning algorithm in Ref 1 adjusts the weights connected to the output layer and then works backward toward the input layer, adjusting weights in each layer. Feedforward networks that use this learning algorithm are called back-propagation networks. Other learning algorithms are also available, and you can develop your own.

Except for simple cases, it is difficult or impossible to know in advance how well a particular neural network will perform in a given application. Therefore, simulation is important for developing neural networks.

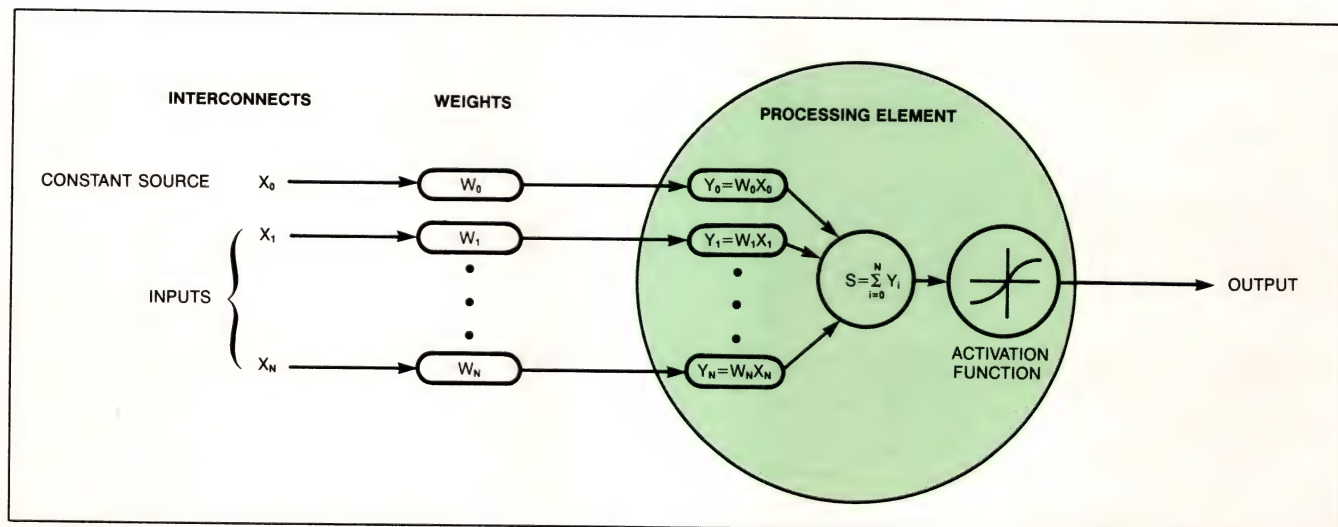


Fig 2—In this depiction of a neural network's components, the inputs X_1 through X_N come from either network inputs or from the outputs of other processing elements.

Most neural networks are currently being simulated and implemented on digital computers. By using the high speed floating-point processors now available, digital computers can perform simulations rapidly even though they are executing an inherently parallel process serially.

Two IBM PC/AT-compatible coprocessor boards suitable for neural-network simulation are the ANZA-Plus, from Hecht-Nielsen Neurocomputers Corp (San Diego, CA, (619) 546-8877), and the Delta FPP, from Science Applications International Corp (San Diego, CA, (619) 546-6290).

The ANZA-Plus coprocessor board supports a total of 2.5 million processing elements and interconnects and costs \$14,900, including software. The Delta FPP coprocessor board supports a total of 3.1 million processing elements and interconnects and costs \$14,895, including software. (Both companies also offer lower performance products with correspondingly lower prices.)

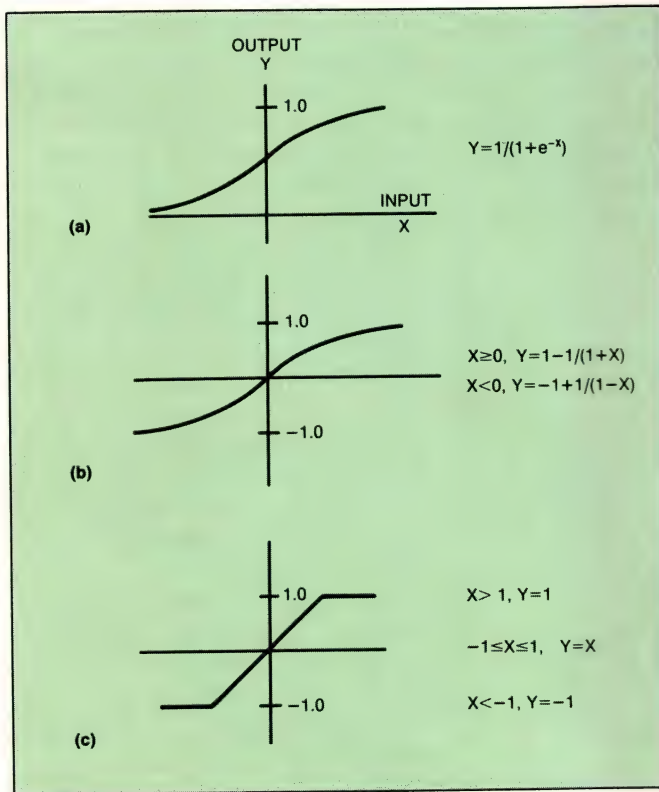


Fig 3—Some typical activation functions include an exponential function that's often used (a), one (b) that's faster to compute in a simulation than the exponential function is, and another (c) that's fast to compute but that places more demands on the learning algorithm.

Neural-network simulation speeds are typically measured using the number of simulated interconnections per second; the ANZA-Plus and the Delta FPP each offer performance in the range of 1 to 10 million interconnections per second, depending on whether the network is in a learning or a nonlearning mode.

To understand how neural networks can be applied to problems, it is instructive to go through the steps involved in developing a simple analog neural network circuit. See box, "Neural network transforms X to sin(X)," for a description of our experience in developing a neural network that performs the X to sin(X) transformation.

An adaptive filter

Feedforward neural networks do not restrict you to simple single-input and single-output applications such as the X- to-sin(X) example. Another simulation we developed was an adaptive filter using 41 taps of an input waveform. These 41 taps provide inputs to a neural network with eight elements in the hidden layer, as shown in Fig 4. This example uses a total of nine processing elements and a total of 345 interconnects.

Text continued on pg 144

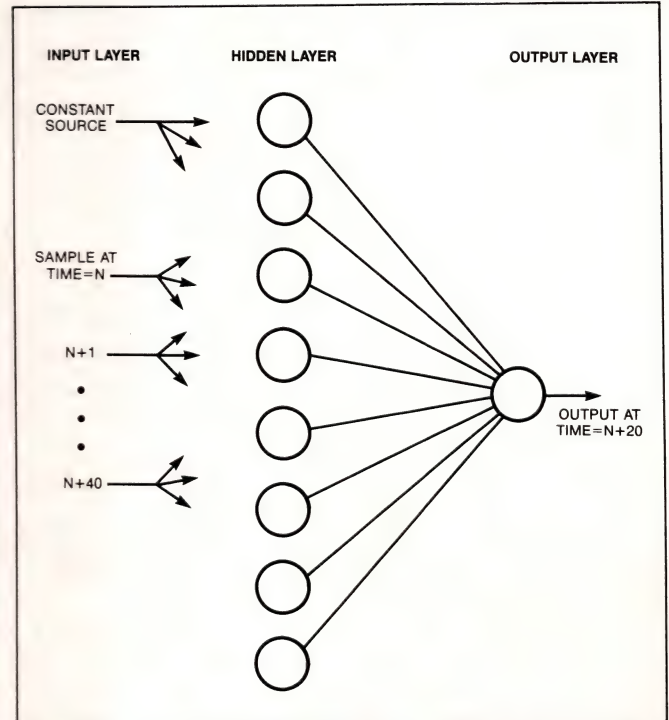


Fig 4—In a 41-tap neural-network filter, each of the 41 inputs is connected to all eight processing elements in the hidden layer. This network has 345 interconnects and nine processing elements.

Neural network transforms X to sin(X)

To learn more about neural networks and to try the concepts in a circuit, we simulated and then built a circuit that performs the transformation of X to $\sin(X)$ for inputs from $-\pi$ to $+\pi$.

The first step was to learn enough about neural networks to understand the details of how they function and to be able to simulate them on a computer. To satisfy both of these requirements we attended a week long course presented by Hecht-Nielsen Neurocomputers. This course taught us the basics about a variety of the most popular neural network architectures. We also learned to simulate neural networks on a PC/AT-compatible computer using the company's ANZA coprocessor board and Neurosoft software. The only prerequisites for this course were a basic familiarity with MS-DOS and a limited ability in C-language programming.

With the knowledge gained from the course, we were immediately able to start simulating neural networks. We decided to use the X-to-sin(X) transformation because it would demon-

strate the operation of a mapping neural network yet be simple enough to allow us to build the neural-network circuit.

We experimented with the feedforward network architecture shown in Fig 1 on pg 139. We tried various numbers of processing elements in the hidden layer and settled on five for the circuit. The hidden layer must have at least three processing elements to represent the basic characteristics of the X-to-sin(X) transformation; additional elements improve accuracy, provided the learning algorithm can make use of the additional elements.

The Neurosoft software package provided with the ANZA coprocessor board would not allow us to modify the activation function. Because we anticipated the need to use a special activation function that would be easy to approximate with an electrical circuit, we decided to write our own simulation program for our X-to-sin(X) neural network.

Without the use of the ANZA coprocessor board to accelerate the floating-point computations required in a neural-network

simulation, our simulation program ran quite slowly, so we took the opportunity to fill the empty 80287 coprocessor socket in our PC/AT. With the coprocessor installed, we saw at least a fourfold improvement in our simulation's execution speed, although the simulation still ran slower than did one running on the ANZA coprocessor board using the canned activation function. Nevertheless, we had the flexibility we needed, and speed was not a problem for the simple network we were simulating.

With a simulation of the neural network to perform the X-to-sin(X) transformation, we were ready to translate the simulation into a circuit. Keeping in mind that we wanted to perform the function shown in Fig 2 on pg 140 with a simple analog circuit, we developed the circuit shown in Fig A.

The circuit is almost an exact analog representation of the desired processing element. Two differences are noteworthy. First, because weights can have both positive and negative values, our Fig A circuit provides complementary outputs, either of which can serve as an input to other processing elements. (We selected the appropriate polarity when installing the weight, or gain-setting, resistors.) The second difference is that our Fig A circuit employs a simple diode clamping circuit for the activation function. We didn't try to approximate a mathematical function such as one shown in Fig 3 on pg 141.

After we developed the Fig A circuit to approximate a processing element, we altered our simulation program to approximate the diode clamping we would be using for the activation function. The neural-network simulation relearned the X-to-sin(X) transformation, and the results of that simulation are the source of

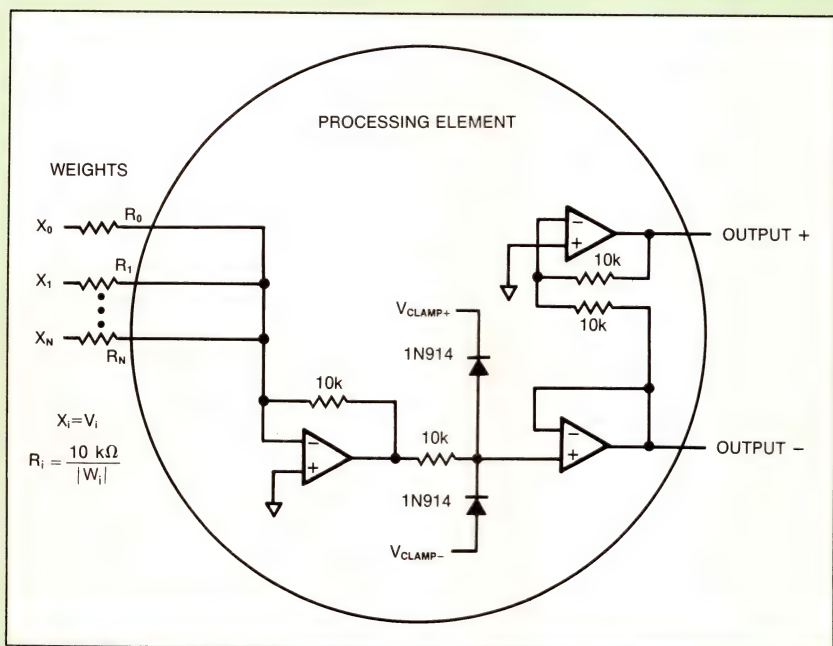


Fig A—A simple analog circuit represents a neural network's processing element.

the weights in Fig 1. The graphic results of the simulation are shown in Fig B.

Confident that our processing element provided an adequate approximation, we designed the

remainder of the circuit, shown in Fig C. We built the circuit, and its response is shown in Fig D. The only change we suggest is to temperature compensate the diode clamping voltages.

This same circuit can approximate $\sqrt{X}$, e^x , and many other continuous functions of one variable; all that would change would be the 16 resistors that represent the weights.

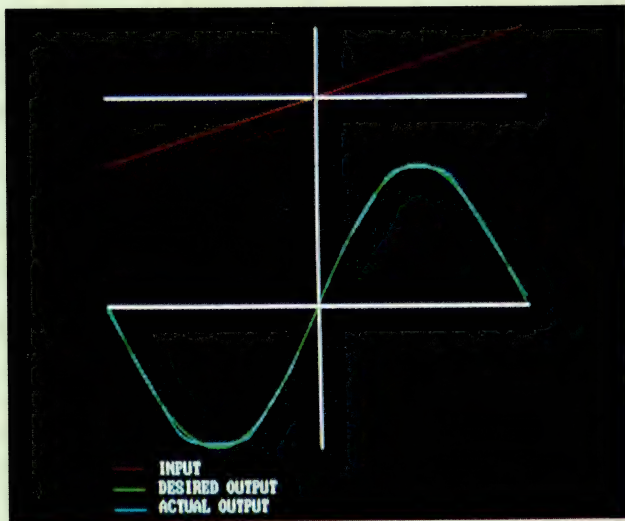


Fig B—Shown here are the graphic results of the neural-network simulation we developed to map X to $\sin(X)$. The input ranges from $-\pi$ to $+\pi$.

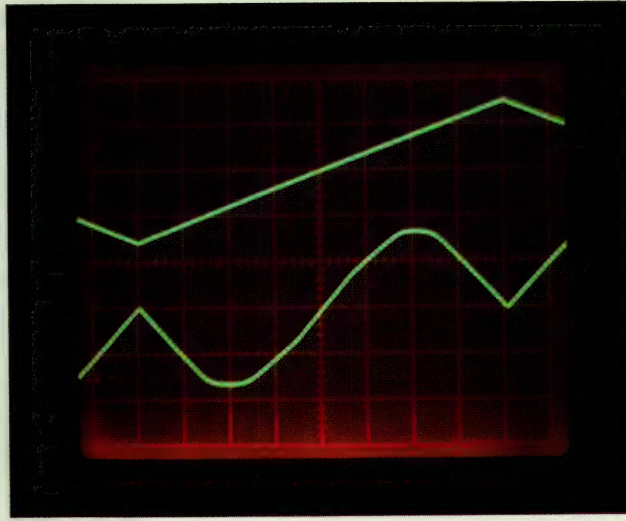


Fig D—The circuit shown in Fig C responds as shown here. The upper trace is the input at 2V/div; the lower trace is the output at 0.5V/div. Sweep speed is 0.1 msec/div.

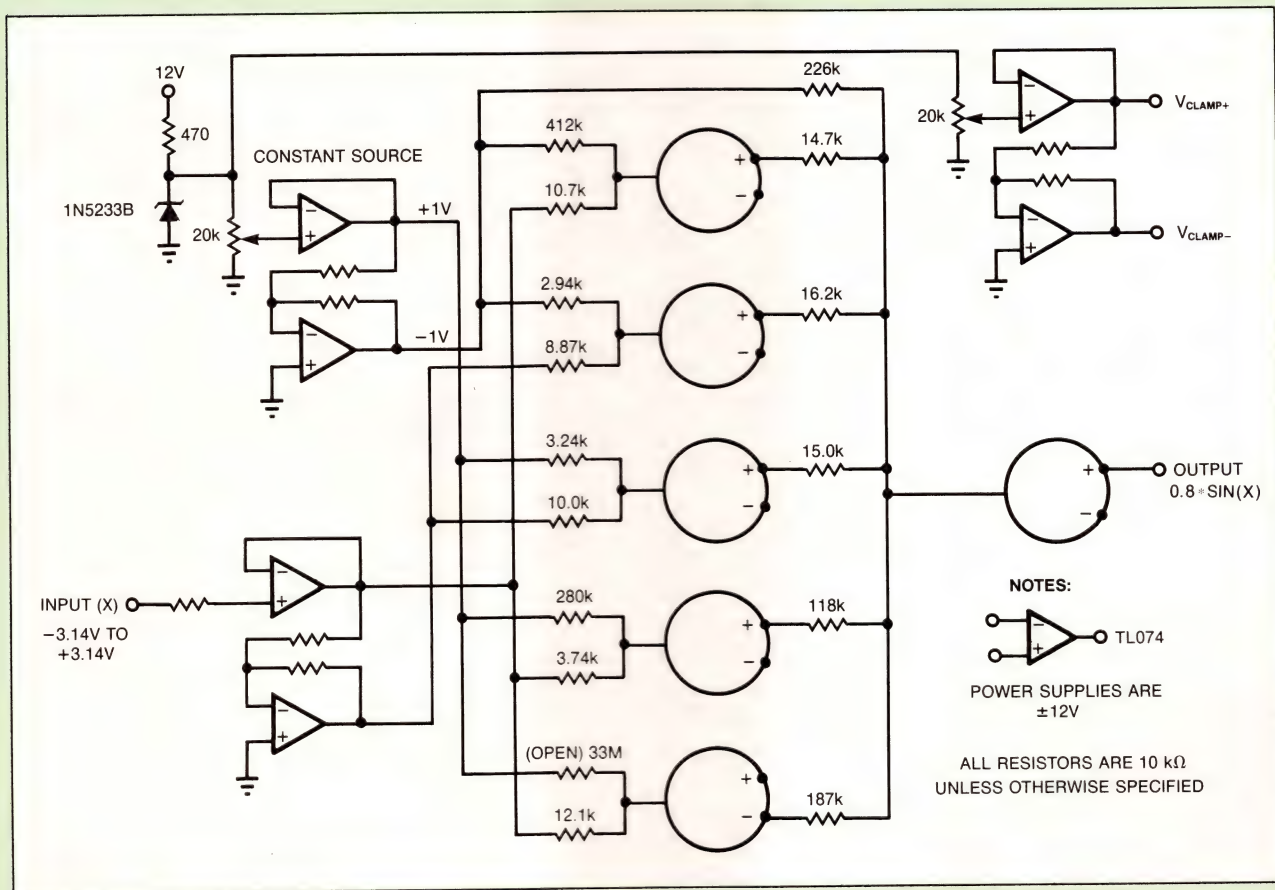


Fig C—This analog circuit represents an implementation of the neural network shown in Fig 1 on pg 139.

Neural networks aren't right for every application, but they do give you another option for solving design problems.

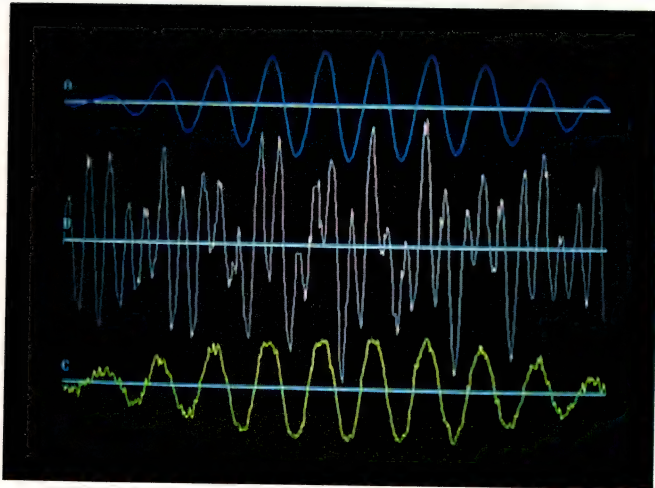


Fig 5—*This figure shows the response of an adaptive neural-network filter. The top trace shows the original signal. The middle trace is the original signal plus noise, which was applied to the 41-tap neural network filter. The bottom trace is the filter's output. The photo was taken after 200,000 learning samples. The noise source was random within frequency and amplitude limits.*

The simulation for this network was run on the ANZA coprocessor board (the precursor to the ANZA-Plus). Fig 5 shows the neural network's response after 200,000 learning samples using the standard back-propagation learning algorithm.

The filter network example had no digital-filtering information programmed into it. We set the initial weights to random values. An interesting and sometimes frustrating feature of neural networks is that for all but the simplest cases, you have no idea how the network is mapping the input to the output. In the filter example you can run sample waveforms through the network and see the response, but that is all you are likely to find out about how the neural network is filtering a signal.

Working with mapping neural networks requires you to look at problems from a different perspective from the one most of us are accustomed to. The normal approach to solving a design or computational problem is to break the problem down into small units and develop an algorithm for each unit. Because neural networks do not require you to develop the algorithm for each unit, you can think of problems in terms of inputs, transformations and outputs.

For example, a typical control-system application can be viewed as a data-transformation problem. Although neural networks probably cannot compete for simplicity in standard linear control applications, neural networks do have potential in nonlinear applications. A neural-

network control system can learn to use nonlinear sensor information and drive nonlinear actuators without requiring you to develop the control algorithms or use lookup tables. You do, however, have to provide a training set.

Neural networks aren't right for every application, but they do give you another option for solving design problems. At present you are limited to either building neural networks at the component level or using virtual neural-network implementations.

Before you can expect to take advantage of the high speeds possible with parallel implementations of neural networks, integrated circuits that pack more neural-network building blocks into one chip are needed. A number of different research organizations are currently working on the problem. As these neural-network building blocks become available, networks with large numbers of processing elements and real-time processing speed should become practical. The means of simulating large networks, however, is available right now.

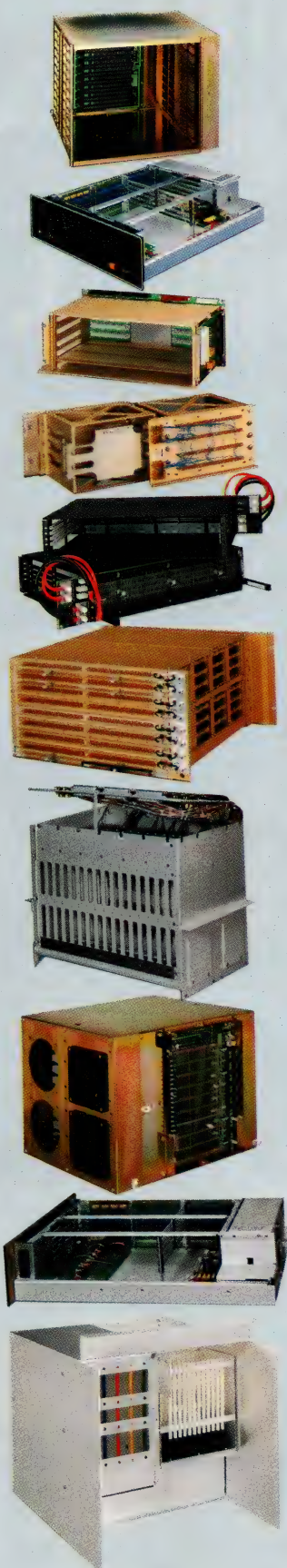
Learning algorithms are the other factor that will determine the ultimate success of neural networks. This isn't to say the learning algorithms in use today can't learn well or quickly. It's just that large, multilayered, networks have considerable capability that demand sophisticated learning algorithms to realize their full potential.

EDN

Reference

1. McClelland, J L, and Rumelhart, D E (PDP Research Group), *Parallel Distributed Processing*, MIT Press, Cambridge, MA, 1986, pgs 318-330.

Article Interest Quotient (Circle One)
High 485 Medium 486 Low 487



For 25 years OEMs have selected SAE to manufacture their backplanes, PCBs, connectors, and card cages. Now they are using us as their manufacturing partner. We take total responsibility to design, fabricate, test and deliver a complete "engineered assembly." This allows the OEM to concentrate all their time and monies on marketing and developing new products — not on new and expanded manufacturing facilities and personnel.

Here's why our customers think of us for all phases of their OEM products:

- **Engineered Assemblies** backplane, wire wrap, card cage, connectors, PCBs, wiring, filters, power supplies, fans, mounting hardware, peripherals, and accessories; complete design, fab and test — ready for your functional test.
- **Military** MIL-28859/28754 backplanes, NAFI headers; PCBs to MIL-P-55110D.
- **Commercial** VMEbus, VERSAbus, S-100, DEC, STD, Multibus backplanes; PCBs, QPL to 16 layers, UL to 4 mils.
- **Assembly and Test** components, wiring and system.
- **Connectors** commercial and military.
- **Filters** EMI/RFI, emission test lab.
- **Magnetic Components** transformers, modules and filters.
- **Card Cages** custom, kits, and accessories.
- **Wire Wrap** semi and automatic, numerous formats and test.

Call, write or FAX for our "engineered assembly" brochure and your local representative/distributor . . . **Think SAE!**



Stanford Applied Engineering

3520 De La Cruz Blvd., Santa Clara, California 95054 • Ph: (408) 988-0700 • Fax: (408) 727-6438
CIRCLE NO 129

Let's Stop All This Finger-Pointing And Get Down To Some Serious Name-Calling.

When something goes wrong with a computer system, everybody wants to know whose fault it is.

We have a better idea.

Solve the problem first. Point fingers later.

As the leading supplier of high performance peripheral sub-systems for VAXs, we've seen

our share of the unspeakable. But we've rarely seen the unsolvable.

We're not just talking about emergency service, either. Anyone can come in, smell smoke, and replace the offending device. We're also talking about things that are much more subtle. Like when your system is red-lined and it's still just too &@\$_%#! slow.

DEC is a registered trademark of Digital Equipment Corporation.



We can look at a whole system and figure out what went south and why. Sometimes better than the people who built it.

You see, what our subsystems and services do best is make Digital Equipment's processors perform better.

And except for those people whose checks are signed "Olsen,"

we have more trained bodies *in the field* to back us up than any other company selling in the DEC marketplace.

So you want to call somebody names?

Call us. **800-333-2220.**

We'll solve your problems faster than you can say "System Industries."



**SYSTEM
INDUSTRIES**

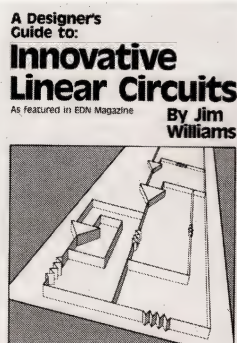
EDN REPRINTS

A Designer's Guide to

Linear Circuits

Volume I:

This original, 186-page collection by Jim Williams offers a wealth of analog design information. It includes practical and efficient ways to use op amps, comparators, data converters, and other analog ICs, and discusses the theories behind all the design techniques presented.

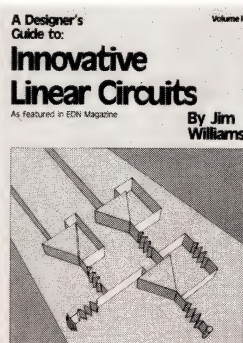


A Designer's Guide to

Linear Circuits

Volume II:

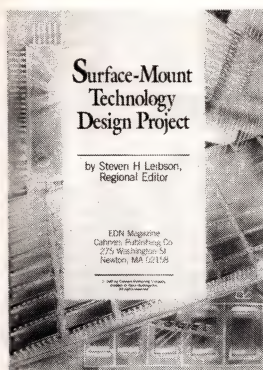
The reader response to Volume I was so positive that we're offering Jim Williams' latest analog design articles—from 1983 to 1986—in an all-new Volume II. An even bigger collection than before, Volume II is still written in the language of working engineers, but now covers the newest and more complex circuits and systems in 266 pages.



You can buy the volumes separately, or as a set. Either way, you'll have all the latest information on the most sophisticated linear ICs, from Jim Williams, one of the country's foremost linear-circuit designers.

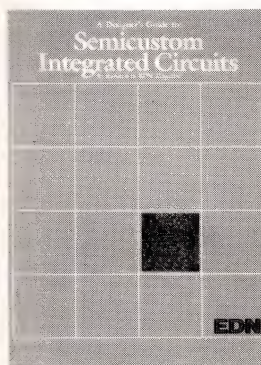
Surface-Mount Technology Design Project

NEW!



Now you can order copies of EDN magazine's exclusive hands-on surface-mount design series. This 48-page, four-color reprint follows the progress of EDN editor Steve Leibson as he designs a 2 Mbyte memory board using surface-mount technology. Leibson takes you from his initial concept through to the finished working product, and includes typical problems you might encounter and objectively reports about both good and bad design decisions made along the way.

A Designer's Guide to Semicustom Integrated Circuits



Learn how to design a semicustom IC with this reprint. Based on EDN's own design experience, this nine-chapter booklet outlines the complete procedure used to design, fabricate, and test EDN 1, a chip with a 1200 equivalent-gate complexity. You'll not only learn the steps to take when creating ICs, but also the design/cost analyses and vendor-interface methods that lead to successful semicustom chips.

Mail coupon to: EDN Reprints, EDN Magazine, Cahners Building, 275 Washington Street, Newton, MA 02158-1630

Please send the following:

— copies of *A Designer's Guide to Innovative Linear Circuits*.

Volume I

☐ \$14.95 (UPS)

☐ \$19.95 (non-USA)

Volume II

☐ \$18.95 (UPS)

☐ \$23.95 (non-USA)

— copies of **the combined set** of *A Designer's Guide to Innovative Linear Circuits Volumes I & II*

☐ \$29.95 (UPS)

☒ \$39.95 (non-USA)

— copies of *Surface-Mount Design Project*

☐ \$7.95 (UPS)

☒ \$10.95 (non-USA)

— copies of *A Designer's Guide to Semicustom Integrated Circuits*

☐ \$6.95 (UPS)

☒ \$10.95 (non-USA)

Please print clearly. This is your mailing label.

EDN051288

Name _____

Title _____

Company _____

Address _____

City _____

State _____

Zip _____

*Check or money order made out to **EDN REPRINTS** must accompany each order. No COD. Mass. residents add 5% sales tax.

Foreign checks must be drawn on a US Bank, issued in US currency.

Consistent expansion of the SMD spectrum: eg integrated circuits from Siemens

If you're going to make full use of the benefits of surface mounting, as many integrated circuits as possible have to be available as SMDs.

So if you've hesitated to change to SMDs until now, it's time to think again. Firstly because you don't want to be left behind. Secondly because Siemens is already offering all its ICs as SMDs.

Especially as MIKROPACKs – the smallest, flattest and lightest of IC formats. MIKROPACKs consist of

- the hermetically sealed chip with solderable contacts and
- films with tin-plated copper tracks.

Siemens can deliver every IC as a MIKROPACK – even microprocessors and custom ICs.

So MIKROPACKs can be used everywhere an IC is used.

There are other standard SMD formats in the Siemens range:

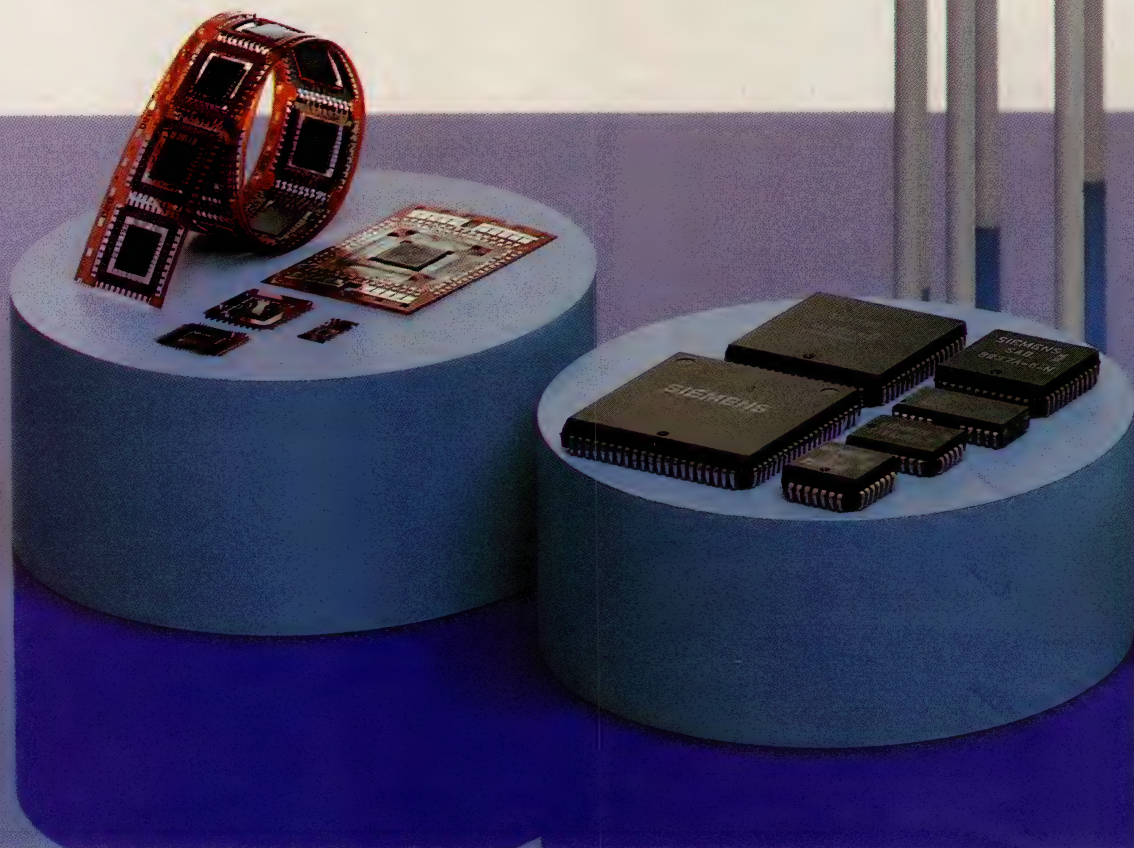
- SO (small outline)
- PLCC (plastic leaded chip carrier)
- LCCC (leadless ceramic chip carrier)

But what's more, Siemens has developed libraries on electronic data media for its SMDs in which all numeric and graphic data are stored ready for CAD. That simplifies and rationalizes the work of PCB layout.

Siemens AG,
Components Group,
Balanstrasse 73,
D-8000 Munich 80

CIRCLE NO 134

12/Z073e





we never stop asking

What if...



Now a network analyzer and a spectrum analyzer in one box. From HP.

The HP 4195A Network/Spectrum Analyzer. It's the *one* tool you've been waiting for to make development and production testing of your analog devices easier, more flexible—and at half the price of equivalent dedicated analyzer solutions and less than other combination units.

For the first time, you have a combination analyzer with a balanced set of specifications for both vector network and spectrum analysis functions. And, if that weren't enough, you can use it for *impedance analysis*, too.

The 10Hz to 500MHz range of the HP 4195A make it ideal for audio, base-band, HF, VHF, and IF applications. A unique feature is four-channel spectrum

measurement capability that accommodates four independent inputs. The unit features an internal flexible disk drive, color CRT, User Math, User Defined Functions, User Programs for customization—and it's softkey menu driven, making it extremely friendly. As usual, HP delivers value.

Call 1-800-752-0900, Ext. B215.

Ask for your free data sheet on the HP 4195A Network/Spectrum Analyzer. Find out how we got network and spectrum analysis tools with balanced performance into one box for half the price.

© 1988 Hewlett-Packard Co. EI15804/EDN
CIRCLE NO 135



**HEWLETT
PACKARD**

EDN May 12, 1988

A systematic approach facilitates noise analysis

You can use a systematic analysis technique to determine the noise contributions of the individual elements in an electronic system, no matter how complex it is. This article, part 1 of a 2-part series, describes the noise-analysis technique. Part 2 will show you how to develop an electronic spreadsheet for evaluating the system's overall noise performance as you modify the individual sections for low-noise performance.

Peter Fazekas, ILC Data Device Corp

The magnitude of the noise in a given system may determine whether the system operates as expected, operates marginally, or doesn't operate at all. When you begin a design, therefore, it's essential to consider the effects of the various noise sources throughout the system. Once you've determined the noise contributions of the individual components, you can optimize the system for low-noise performance by replacing or modifying the sections you identify as problem areas.

The task is a complex one, however. Many different noise sources can contribute to the total noise in a system, and when you optimize a particular circuit section to maximize its performance or minimize its noise contribution, you may inadvertently increase the noise in other sections. Systems that have a large

number of noise sources are often difficult to optimize for low-noise performance.

Tasks of this nature and complexity have long been a part of the business world in the form of "what-if" forecasting. The basic tool for this type of analysis is a spreadsheet program that presents statistical data in tabular form. An electronic spreadsheet can instantly show the effects of a change in any single parameter on the overall results. You can use this type of analysis to evaluate the effects of circuit changes on the overall noise performance of a system. Before you can perform such an analysis, however, you must first develop a mathematical model that represents the system in a suitable form.

The effects of noise in linear systems

The three types of noise you must consider when analyzing the performance of devices and circuits are thermal noise, shot noise, and 1/f noise (see **box**, "The physics of noise"). When optimizing the noise performance of a system, you'll have to determine the actual amount of noise voltage or noise current generated by each component.

If you apply a source having a voltage power spectral density of $P_V(f)$ IN to a circuit with a voltage transfer function of $H_V(f)$, the resultant output-voltage power spectral density is

$$P_V(f) \text{ OUT} = P_V(f) \text{ IN} \cdot |H_V(f)|^2.$$

The three types of noise most important to electronic-circuit designers are thermal noise, shot noise, and 1/f noise.

The rms value of the voltage represented by the output power spectral density is

$$\sqrt{V_{OUT}^2} = \left[\int_0^\infty P_V(f)_{OUT} \cdot df \right]^{1/2}.$$

Referenced to the source, the rms value of the voltage is

$$\sqrt{V_{OUT}^2} = \left[\int_0^\infty P_V(f)_{IN} \cdot |H_V(f)|^2 df \right]^{1/2}.$$

You can represent the power spectral density of a noise source as either a voltage source, $P_V(f)$, in series with its generating resistance R , or a current source, $P_I(f)$, in parallel with resistance R . You can convert from one type to the other in the following manner:

- The value of the voltage power spectral density divided by the series resistance squared gives the current power spectral density: $P_I(f) = P_V(f)/R^2$.
- The value of the current power spectral density multiplied by the parallel resistance squared gives the voltage power spectral density: $P_V(f) = P_I(f) \cdot R^2$.

For example, the voltage power spectral density of the noise generated by a resistance, R , is $P_V(f) = 4KTR$; as a current power spectral density, the noise is

$$P_I(f) = 4KTR/R^2 = 4KT/R.$$

You can also express the transfer function of the circuit as any combination of voltage or current input and voltage or current output. You should take care to use the correct form of the transfer function so as to match the input form to the type of output required.

Because the shape of an arbitrary filter can take a number of forms, the filter's -3-dB point alone can't define its noise characteristics. To determine total noise output, you can use the concept of noise equivalent bandwidth (NEBW). The NEBW of a circuit is the bandwidth of an ideal filter (with vertical sides and identical midband gain) that passes the same amount of power that the real filter does. In this case, bandwidth is defined as the difference between the high and low corner frequencies of the ideal filter.

Therefore, the value of the power (voltage squared) due to a source $P(f)$ passed through a circuit with a transfer function $H(f)$ is

$$\overline{V_{OUT}^2} = \int_0^\infty P(f)_{IN} \cdot |H(f)|^2 df.$$

If the function $P(f)$ is independent of frequency (as with thermal or shot noise at low frequency) you can move it outside of the integral sign, which results in

The physics of noise

The three types of noise you generally need to consider when designing electronic circuits are thermal noise, shot noise, and 1/f noise.

Thermal noise derives its name from its characteristic change in magnitude as a function of temperature. Any material that conducts electricity does so as a result of the free electrons that exist in the volume of the substance. These electrons are in constant motion, randomly colliding with each other. On the average, these electrons are evenly distributed throughout the bulk of the material. However, because of their random action, they do exhibit a

statistical deviation from neutrality.

The effect of this deviation is to generate a voltage drop at the terminals of the conductor. The higher the temperature, the more energy the free electrons have, which greatly increases the probability that the electrons will be unevenly distributed. This uneven distribution results in a higher output voltage. Thermal noise, which is zero for a perfect conductor, also increases with an increase in the value of any resistance. The voltage power spectral density of thermal noise is $P_V(f) = 4KTR$, where $P_V(f)$ is the frequency-dependent voltage power spectral

density, K is Boltzman's constant ($1.38 \cdot 10^{-23}$ J/°K), T is the temperature in °K, and R is the resistance of the material in ohms.

Thermal noise exhibits no change in magnitude as a function of frequency, and can be considered to be *white noise*, whose name implies that all frequencies are present (just as all colors are present in white light). The contribution of white noise is limited only by the bandwidth of the circuit.

Shot noise is caused by the quantum nature of electron flow. In semiconductor devices, this effect is due to the random diffusion of minority carriers and the

$$\overline{V_{OUT}^2} = P(f)_{IN} \cdot \int_0^\infty |H(f)|^2 df.$$

The second half of this equation, normalized to unity, is the NEBW of the circuit. The resulting NEBW is

$$1/|H(f_m)|^2 \cdot \int_0^\infty |H(f)|^2 df,$$

where $H(f_m)$ is the transfer function at the midband frequency, f_m .

A sample calculation illustrates the approach. Let the filter be a simple first-order lowpass type with

$$H(f) = 1/(1 + j(f/f_c)),$$

where f_c is the -3-dB frequency.

The midband gain, $H(f_m)$, is unity, and

$$|H(f)|^2 = 1/(1 + (f/f_c)^2).$$

Therefore, the NEBW is

$$1 \cdot \int_0^\infty 1/(1 + (f/f_c)^2) df.$$

Since, by definition, $\int 1/(1 + U \cdot f) df = 1/\sqrt{U} \cdot \arctan(f \cdot \sqrt{U})$, and the substitution $U = 1/f_c^2$ can be made, the NEBW is

$$1/f_c \cdot \arctan(f/f_c) \Big|_0^\infty = \pi/2 \cdot f_c - 0 = \pi/2 f_c.$$

For a lowpass filter, the NEBW is $\pi/2 \cdot f_c$; for a highpass filter, the NEBW is $2/\pi \cdot f_c$.

The value $\sqrt{P(f)}$ is often provided by component manufacturers and referred to as the equivalent input noise in units of volts per root hertz ($V/\sqrt{Hz}$) or amps per root hertz ($A/\sqrt{Hz}$). The rms voltage at the output of the filter having a flat input-noise spectral density is

$$\sqrt{P(f)_{IN}} \cdot \left[\int_0^\infty |H(f)|^2 df \right]^{1/2}.$$

Evidently, this value is simply the input equivalent noise multiplied by the square root of the NEBW.

Filtered noise characteristics

Assuming that it's flat with respect to frequency, the total rms noise passed through a filter is the equivalent input noise multiplied by the square root of the NEBW. For example, a standard 741 op amp has a white-noise

random generation and recombination electron-hole pairs. At a given temperature and voltage, the current flowing through a semiconductor will be relatively constant. This current is the result of a large number of electrons flowing in the same general direction; each electron has a random component. It is this random component that causes shot noise. The current power spectral density of shot noise is $P_i(f) = 2qi$, where $P_i(f)$ is the frequency-dependent current power spectral density, q is the charge on one electron ($1.59 \cdot 10^{-19} C$), and i is the current flowing through the device. As is the case with thermal noise, shot noise is inde-

pendent of frequency to very high frequencies, and it can be considered to be white noise.

As its name implies, $1/f$ noise has a voltage power spectral density that varies as $P_v(f) = Kf/f^a$, where Kf is a device parameter (such as $1 \mu V$ in the relationship $1 \mu V/\sqrt{Hz}$) and a is a factor between 0.8 and 1.4 (but it's normally set to 1).

This type of noise exists in all electrical devices—it has been measured in bulk resistors, junction semiconductors, metal film, superconductors, and electrolytic solutions. Regardless of where it occurs or what causes it, noise that varies with frequency is usually called $1/f$ noise. It's also

referred to as current noise, excess noise, flicker noise, semiconductor noise, and contact noise.

The cause of $1/f$ noise is not well understood, but current knowledge of this type of noise is drawn from a large pool of experimental data. Noise of this power spectral density is measurable and observable in the 10^{-6} - to 10^6 -Hz range, which agrees with theoretically predicted levels.

Because the magnitude of thermal noise is frequency independent over the circuit's bandwidth, it falls into the category of white noise.

floor that's specified as $15 \text{ nV}/\sqrt{\text{Hz}}$. If this noise passes through a filter with an NEBW of 10 kHz, the total rms voltage at the output is

$$15 \text{ nV}/\sqrt{\text{Hz}} \cdot \text{NEBW} = 1500 \text{ nV}$$

If the noise spectral density is not independent of frequency, you'll have to evaluate the integral of

$$V_{\text{OUT}} = \left[\int_0^\infty P_V(f)_{\text{IN}} \cdot |H(f)|^2 df \right]^{1/2}$$

Designers frequently use numerical methods for the integration because the integration is often complex.

A common noise spectral density that's frequency dependent is $1/f$ noise, which has a voltage power spectral density of $P_V(f) = e_n/f^a$ (a is set at unity). The rms voltage due to this type of source is

$$V_{\text{OUT}} = \int_{f_L}^{f_H} (e_n/f) df = e_n \cdot \log n(f) \Big|_{f_L}^{f_H}$$

If you take the low-frequency limit as 0 Hz, the output voltage is infinite. To have a true 0-Hz limit, the circuit would have to exist in its On state for an infinite period of time. Even a measurement period of 30 days generates a low-frequency limit of only 0.00000039 Hz, thus limiting the total noise to a finite value.

You determine the total rms noise voltage by evaluating V_{OUT} with the appropriate frequency limits. These frequencies are the corner points of the ideal filter, represented by the NEBW. For example, assume you wish to calculate the rms noise voltage of a circuit with the following characteristics:

- First-order low-frequency corner at 0.3 Hz
- First-order high-frequency corner at 30 kHz
- $1/f$ noise source of $1 \text{ nV}/\sqrt{\text{Hz}}$ at 1 kHz

The results of the calculations are

- Low-frequency corner: $f_L = 0.3 \cdot (2/\pi) = 0.191 \text{ Hz}$
- High-frequency corner: $f_H = 30,000 \cdot (\pi/2) = 47.124 \text{ kHz}$
- Total rms noise voltage: $1 \text{ nV} \cdot \log_n(f_H/f_L) = 12.4 \text{ nV}$

Multiple filter combinations

In a system that has a number of filters in the noise path, each with different frequency characteristics, you'll have to combine these characteristics into a final result to determine the NEBW of the circuit. This process is often long and difficult because of the com-

plexity of the integrations. If an approximation of the NEBW is adequate, the following relationships are useful: If two first-order filters are in series, the combined filter has an NEBW higher than either one for highpass filters, and lower than either one for lowpass filters. If the ratio of the higher-to-lower corner frequency is R , then the ratio of the combined NEBW to the -3-dB corner frequency of the dominant pole is equal to $\pi/2 \cdot (1 - (1/1+R))$ for a lowpass filter and $2/\pi \cdot (1 - (1/1+R))$ for a highpass filter. The coefficient $(1 - (1/1+R))$ adjusts the NEBW of the dominant frequency.

If more than two filters are in series, you should combine their characteristics by calculating the NEBW for the first two, and then combine the result with the next filter. You continue this process until you've considered all of the filters. For example, if there are two first-order lowpass poles, one at 10 Hz and the other at 45 Hz, the ratio R is 4.5 and the correction factor is $1 - (1/(1+R)) = 0.818$. The NEBW of the dominant 10-Hz pole is 15.7 Hz, and the combined NEBW of the two filters is $15.7 \cdot 0.818 = 12.85 \text{ Hz}$.

Superposition and noise-source combinations

The superposition theory holds for noise sources in the frequency domain. In other words, if two independent sources, $V_1(t)$ and $V_2(t)$, are summed to form $V(t)$, the resultant power spectral density is $P_V(f) = P_1(f) + P_2(f)$. The implication is that when two sources are combined, the rms value of the result is equal to the root of the sum of the squares of the rms value of the individual sources.

You can extend this principal to an arbitrary number of sources. If you write the rms value of each noise source as V_N , the total output is

$$V_T = \sqrt{V_1^2 + V_2^2 + V_3^2 \dots V_N^2}$$

By using this theory, you can evaluate the total noise of a large system that has multiple noise sources. With this basic knowledge of the properties of electronic noise and how it behaves in electrical circuits, you've taken the first step in being able to predict the noise performance of entire systems. The next step is to understand the noise contributions of the individual components.

The dominant noise in bulk conducting material is thermal noise. The model used to represent bulk material is a noiseless resistor with an ohmic value the same as that of the bulk material, and an ideal noise source

(either in series with or parallel to the resistor). If the source is in series, it has a voltage power spectral density of $P_V(f) = 4KTR$. If the source is parallel, it has a current power spectral density of $P_I = 4KT/R$. $P_V(f)$ and $P_I(f)$ are the voltage and current power spectral densities, respectively; K is Boltzman's constant ($1.38 \cdot 10^{-23}$ J/°K; T is the temperature in °K; R is the resistance in ohms.

The actual noise measured may be greater than the predicted value. This additional noise is known as excess noise, and it has a $1/f$ spectral response. This noise is proportional to the voltage drop across the resistor and is usually defined by a quantity called the "noise index." The noise index (measured in dB) is the microvolts of noise per dc volts across the resistor in each decade of frequency. The amount of excess noise depends on the method of manufacture of the resistor. Carbon-composition resistors generally have a noise index in the range of +10 to -20 dB. Carbon-film resistors range from -10 to -25 dB, and metal-film resistors and wire-wound resistors range from -15 to -40 dB. **Fig 1a** illustrates the model.

You can model a junction diode (**Fig 1b**) by a resistor (R_S), which represents the ohmic region of the diode, in series with a current source (I_D), which represents the diode current. The thermal noise of the diode has a current power spectral density of $P_I(f) = 4KT/R_S$. The noise representing the current source has two components: shot noise and $1/f$ noise. Shot noise has a current power spectral density of $P_I(f) = 2q \cdot I_D$, where q is the charge on one electron. The $1/f$ noise has a current power spectral density of

$$P_I(f) = (Kf/f^a) I_D^{Af}$$

You must determine the values of Kf , Af , and a either experimentally or from curves provided by the manufacturer. Kf is a device constant, Af is a process parameter, and a is a constant with a value near unity. The characteristics of the device and the nature of the circuit that it's used in determine the need to include the $1/f$ component in the overall evaluation.

Fig 1c is a simple model of a bipolar junction transistor (BJT). The three resistors produce current power spectral densities of $P_I(f) = 4KT/R_B$, $P_I(f) = 4KT/R_C$, and $P_I(f) = 4KT/R_E$. The base-current source contains components of shot noise and $1/f$ noise, and has a current power spectral density of:

$$P_I(f) = 2q \cdot I_B + (Kf/f^a) I_B^{Af}$$

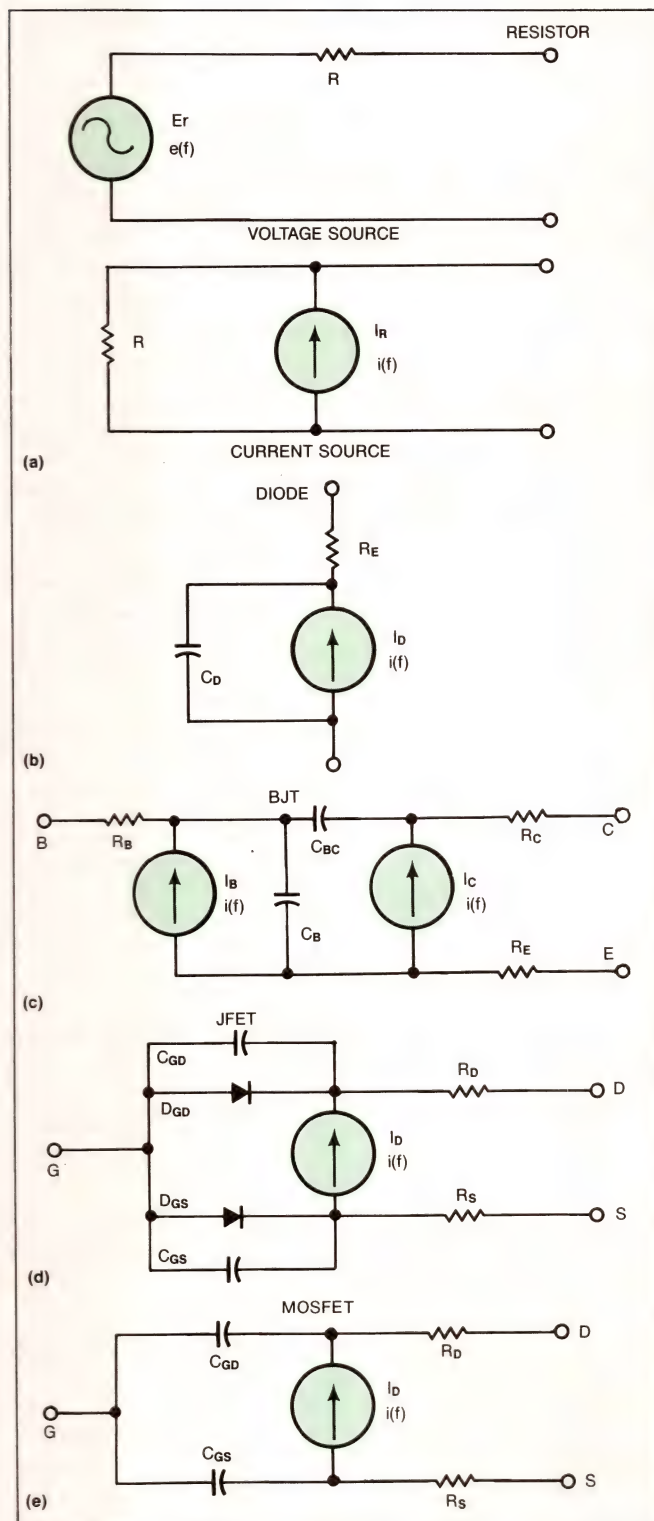


Fig 1—You can use these models to evaluate the noise characteristics of passive and active components.

As its name implies, 1/f noise is frequency dependent. Although it exists in all electrical devices, 1/f noise is poorly understood.

The collector-current source has only a shot-noise term; it has a current power spectral density of

$$P_I(f) = 2q \cdot I_C$$

You can modify the transistor model to suit the conditions under which you use it, adding second-order components as necessary. Resistors will contribute thermal noise to the model, and capacitors will alter the transfer function between the source of noise and the measurement point (the system's output).

Noise models for JFETs and MOSFETs

Fig 1d is a representative model of a JFET. The drain resistor (R_D) and the source resistor (R_S) contribute thermal-noise components that have current power spectral densities of $P_I(f) = 4KT/R_D$ and $P_I(f) = 4KT/R_S$. The drain current flows through the variable bulk resistance of the channel, which is not a semiconductor junction. For this reason, the noise power spectral

density is that of the equivalent channel resistance:

$$P_I(f) = 4KT/R_D + (Kf/f^a) \cdot I_D^{Af},$$

where R_D is the small-signal channel resistance at the operating point. Because the conductance of the channel ($1/R_D$) is equal to $\frac{2}{3} \cdot g_m(\text{sat})$ over the normal biasing range, the current power spectral density is

$$P_I(f) = 8KT \cdot g_m(\text{SAT})/3 + (Kf/f^a) \cdot I_D^{Af}.$$

Note that a good silicon JFET has no observable 1/f noise, and its Kf coefficient is zero. Gallium arsenide JFETs do exhibit 1/f noise, and you'll have to include that noise in your calculations.

Fig 1e is the model for a MOSFET. The formulas for the current power spectral density of the drain resistor and the source resistor are the same as those for the JFET, as is the formula for the drain-current power spectral density.

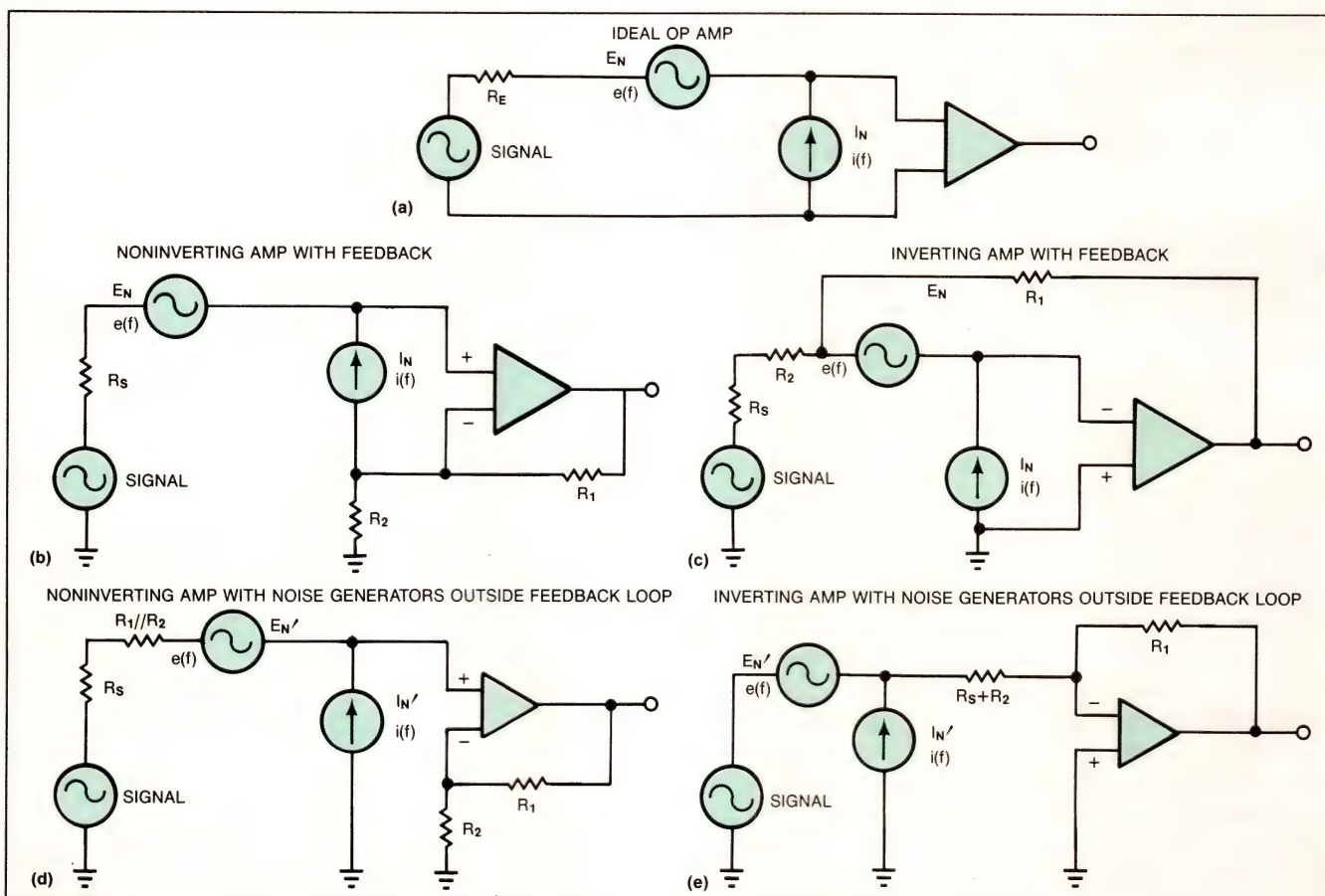


Fig 2—For evaluating op amps in various configurations, you can use the noise models shown here.



PHILIPS

Taking the lead in VERSATILITY and SPEED!

Philips' new PM 5785 and PM 5786 pulse generators set the pace in speed, versatility and ease of operation.

Fast because they cover virtually any linear and digital requirement with speeds up to 125 MHz/1 ns transition time.

Versatile because they feature dual output channels with a choice of bipolar, positive and negative pulses and a very wide selection of external trigger and gate functions.

And they're **Easy to use** because erroneous time settings are clearly indicated, and a preset burst mode (optional) facilitates testing: memories, shift registers, counters and other digital circuits.

The PM 5786 features continuously variable rise/fall times from 2 ns to 0.1 s while the extra fast PM 5785 has fixed selectable rise/fall times of 1 ns, 1.5 ns or 2 ns (from 700 ps for 20%...80% for ECL).

Product credibility in technology, technique, quality and service also is assured because the PM 5785 and PM 5786 are backed by the resources of one of the world's largest electronics companies.

For further information, call your local supplier:

Austria* (222) 629141, **Belgium** (2) 5256692/94,
Denmark* (1) 572222, **Finland*** (0) 5257225, **France** (1)
49428080, **Germany** (561) 5010, **Great Britain** (223)
358866, **Ireland** (1) 952501, **Italy*** (39) 3635240/8/9,
Netherlands (13) 352455, **Norway*** (2) 680200,
Portugal* (1) 683121, **Spain*** (1) 4042200, **Sweden** (8)
7821800, **Switzerland** (1) 4882211.

***For Philips products only.**

For countries not listed, write to: Philips I&E, T&M Department, Building HKF, 5600 MD Eindhoven, The Netherlands.

ADVANCED TECHNOLOGY
MADE TO MEASURE

PHILIPS



To properly evaluate the noise contributions of active and passive devices, you must first construct an accurate model.

You can represent the model of a noisy op amp by a noiseless op amp (**Fig 2a**) and two noise sources, one a voltage source and the other a current source. Each of these sources has a white-noise component that's independent of frequency, and each sometimes has a significant 1/f component.

In practice, you always set up an op amp as either an inverting amplifier (**Fig 2c**) or a noninverting amplifier (**Fig 2b**) that includes resistors in the circuit to set the gain. To simplify the evaluation of the magnitude of each noise source at the output of the amplifier, you can bring the sources outside the feedback loop.

Fig 2d shows the noninverting configuration. R_1 and R_2 , which are in parallel, simulate the current noise flowing in the feedback resistors, and the thermal noise of the two resistors is added to the value of E_N' so that

$$E_N'^2 = E_N^2 + (4KT \cdot (R_S + R_1 \parallel R_2))^2$$
$$I_N' = I_N.$$

To obtain the inverting configuration, you can move the sources outside the feedback loop if you add the noise generated by the feedback resistors (**Fig 2e**). The sources take on the following new values:

$$E_N'^2 = E_N^2 + (4KT \cdot (R_S + R_2))^2$$
$$\text{and } I_N'^2 = I_N^2 + (4KT/R_1)^2.$$

You can find out the op amp's noise characteristics from its data sheet. The data sheet usually gives the white-noise component (comprising thermal noise and shot noise) in $A/\sqrt{\text{Hz}}$ or $V/\sqrt{\text{Hz}}$, either of which is the square root of the power spectral density, and represents the amount of noise in a 1-Hz segment of the spectrum. The data sheet usually gives the 1/f noise as the 1/f corner frequency, and, at this frequency, the amplitudes of the 1/f noise and the white noise are equal. Because the amplitude of the 1/f noise at a specific frequency is known, and the shape of the power spectral density curve is $\Pi(f) = Kf/f^a$, you can generate the equation for the overall curve. If you don't have a value for the a coefficient, you can set it to 1 without significant error.

Digitization noise

An A/D converter takes a continuous function of time and breaks it into discrete steps represented by a digital word. By its very nature, the digital representation of the voltage is an approximation. This approximation introduces a quantization error at each conversion,

which is observable as quantization noise. This noise is equal to the amplitude of 1 LSB of the A/D converter, multiplied by $\sqrt{12}$.

In general, electronic systems use two different types of transducers: passive and active. A passive transducer modifies a reference voltage or current according to external stimuli. Resistive strain gauges and carbon microphones are examples of passive transducers. An active transducer produces a current or voltage that is proportional to the external stimuli. Piezoelectric crystals and photovoltaic cells are examples of active transducers.

In analyzing each type of transducer for noise performance, consider that resistive components will contribute thermal noise, and active sections will contribute shot noise and (possibly) 1/f noise. In passive transducers, the power source adds to the total noise.

In addition, background acoustic noise from a microphone or mechanical vibration from a strain gauge can generate transducer-related noise in the system you're measuring. These factors are beyond the control of the electronic designer, and they set an upper limit on the system's signal-to-noise ratio. In a background-limited system, the electronic circuits contribute less noise than does the background, and no further electronic improvements are necessary.

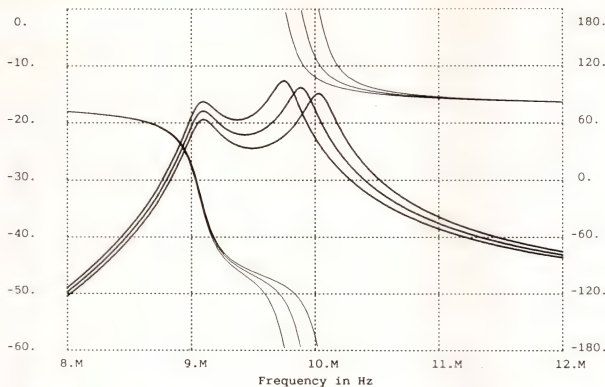
Power-supply noise contributions

Further, don't ignore the noise contributions of the power supply. Every component that operates from the power supply has a limited ability to isolate noise at its supply terminals and prevent that noise from passing through to the circuit's output. This ability is called the power-supply rejection ratio (PSRR), and it's usually expressed in dB. For example, a PSRR of 20 dB means that the noise passing into the signal path from the power supply is attenuated by 20 dB. In the case of active components, this noise is multiplied by the stage gain.

The PSRR curve is not independent of frequency. It has approximately the same shape as a first-order lowpass filter: It's essentially flat until the breakpoint, and then it decreases at a rate of 20 dB per decade. To perform noise analysis, you apply a source (specifically, a source whose noise spectrum is identical to that of the power supply) to the input of the amplifier through a lowpass filter. This filter's attenuation characteristics should be the same as the PSRR curve of the amplifier. If, for example, the PSRR of the amplifier is 80 dB, the filter should have 80 dB of attenuation to the specified

ANALOG CIRCUIT ANALYSIS

ECA-2



ECA-2 is a high performance, low cost analog circuit simulator. **ECA-2 2.31** includes more models, increased graphics capabilities, increased AC analysis speed, and expanded documentation. **Now available for the Macintosh.**

ECA-2 Offers

- AC, DC, Transient
- Fourier, Temperature
- Worst-case, Monte Carlo
- Full nonlinear simulator
- Interactive or batch
- SPICE compatible models
- Twice as fast as SPICE
- Over 500 nodes
- Sine, Pulse, PWL, SFFM, and Exponential generators
- Money back guarantee

ECA-Ace, a subset of **ECA-2**, \$145

ECA-2 IBM PC or Mac \$675

Call 313-663-8810 For **FREE DEMO** disk



CIRCLE NO 16

FREE
160-page catalog

Just in time delivery

on over 100,000
electronic hardware parts.

We've been cutting our customers' inventory costs with "JUST IN TIME DELIVERY" for ten years. We stock over 80% of our items for immediate shipment to your scheduled delivery dates. Non-catalog or out-of-stock parts are shipped within a few weeks.

We manufacture our own parts to ensure consistent high quality. When you need special hardware, we custom-manufacture to your blueprint in any quantity, from small lot to high volume.

For quality, selection, competitive pricing, and "JUST IN TIME DELIVERY," depend on RAF. Write or call today for our free catalog, or a quotation.

RAF

Electronic Hardware, Inc.

95 Silvermine Road • Seymour, CT 06483
(203) 888-2133 • FAX (203) 888-9860



CIRCLE NO 17

breakpoint, and then should reduce its attenuation by 20 dB per decade.

Power-supply noise can take the form of white noise (both thermal noise and shot noise), 1/f noise, and noise at discrete frequencies such as 60 Hz. This noise usually has some form of bandlimiting, either in the power supply itself or outside the power supply. The attenuation of the filter limits the amount of noise entering the system.

Once you've analyzed both the noise characteristics of the components in an electronic system, and the way the system modifies the noise, you need only compile the results to understand the system's entire operation. Part 2 of this series will demonstrate a method for compiling the results with an electronic spreadsheet.

EDN

References

1. Bohn, D, *Audio Handbook*, National Semiconductor Corp, 1976.
2. Buckingham, M J, *Noise in Electronic Devices & Systems*, John Wiley & Sons, New York, NY, 1983.
3. Fitchen, F C, *Low Noise Electronic Design*, John Wiley & Sons, New York, NY, 1973.
4. Lathi, B P, *Signals, Systems & Communications*, John Wiley & Sons, New York, NY, 1965.

Author's biography

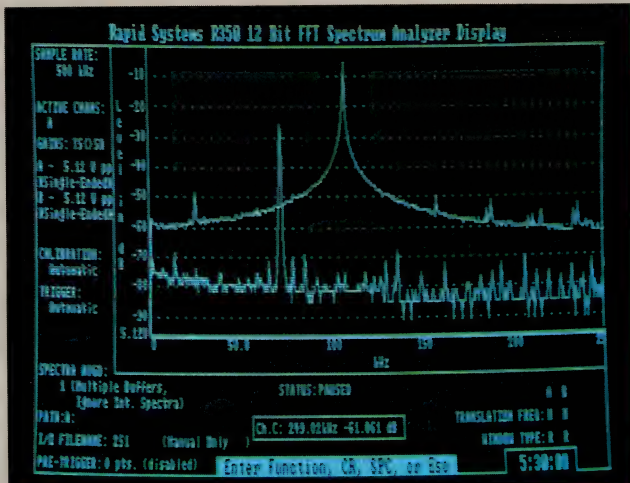
Peter Fazekas is a senior design engineer at ILC Data Device Corp (DDC) (Bohemia, NY), where he's currently responsible for the design of hybrid microcircuits. Before joining DDC two years ago, he was employed by Spar Aerospace Ltd in Toronto, Canada. Peter holds a BA in science from the University of Toronto. In his spare time, he enjoys racquetball, scuba diving, and underwater photography.



Article Interest Quotient (Circle One)
High 482 Medium 483 Low 484

12 BIT TIME & FREQUENCY FOR \$3995!

TIME OR FREQUENCY AT THE PUSH OF A BUTTON.



The R350 is a PC-based 12-bit, 2-channel, 500 KHz, real-time, FFT spectrum analyzer. Sample 2 channels simultaneously. 32K data buffers. Autosave spectrums to hard or floppy disk. Two modes of spectrum averaging. Fully differential inputs. Linear or log amplitude scaling. Amplitude and frequency cursor. Display spectrums 5 to 10 times a second. Print, store, retrieve and overlay spectrums. 500 KHz anti-aliasing filters on each channel, 80db of dynamic range.



The R350 is a PC-based 12-bit Digital Oscilloscope. Sample 2 channels simultaneously at 1 MHz. 32K data buffers per channel. EMI protected metal case with power supply. Switchable differential or single ended input impedance. Software-selectable gain ranges allow resolution of 200 μ V to 500 volts. Full analog and 100% digital triggering. Trigger adjust potentiometer. Fully differential inputs for signal integrity. Vertical waveform zooming. Autosave. Software drivers for "C", BASIC, and Turbo-Pascal.

At Rapid Systems, 12 bit spectrum analyzers and digital oscilloscopes are no longer separate and distinct instruments, each with its own high cost.

Now you can afford both, in one PC-based instrument: the Rapid Systems R350.

A 12 bit, 1 MHz, 2-channel FFT analyzer and digital scope for only \$3995.



PC-based to make you more productive.

The R350 is PC-based, of course. All Rapid Systems instruments are PC-based: designed, manufactured and tested to be ready to operate, the minute you receive them.

Plug the R350 into a personal computer, slip in the software disk, and you're ready to go to work. Totally turnkey. It's that simple and easy to use.

Call now for a demonstration.

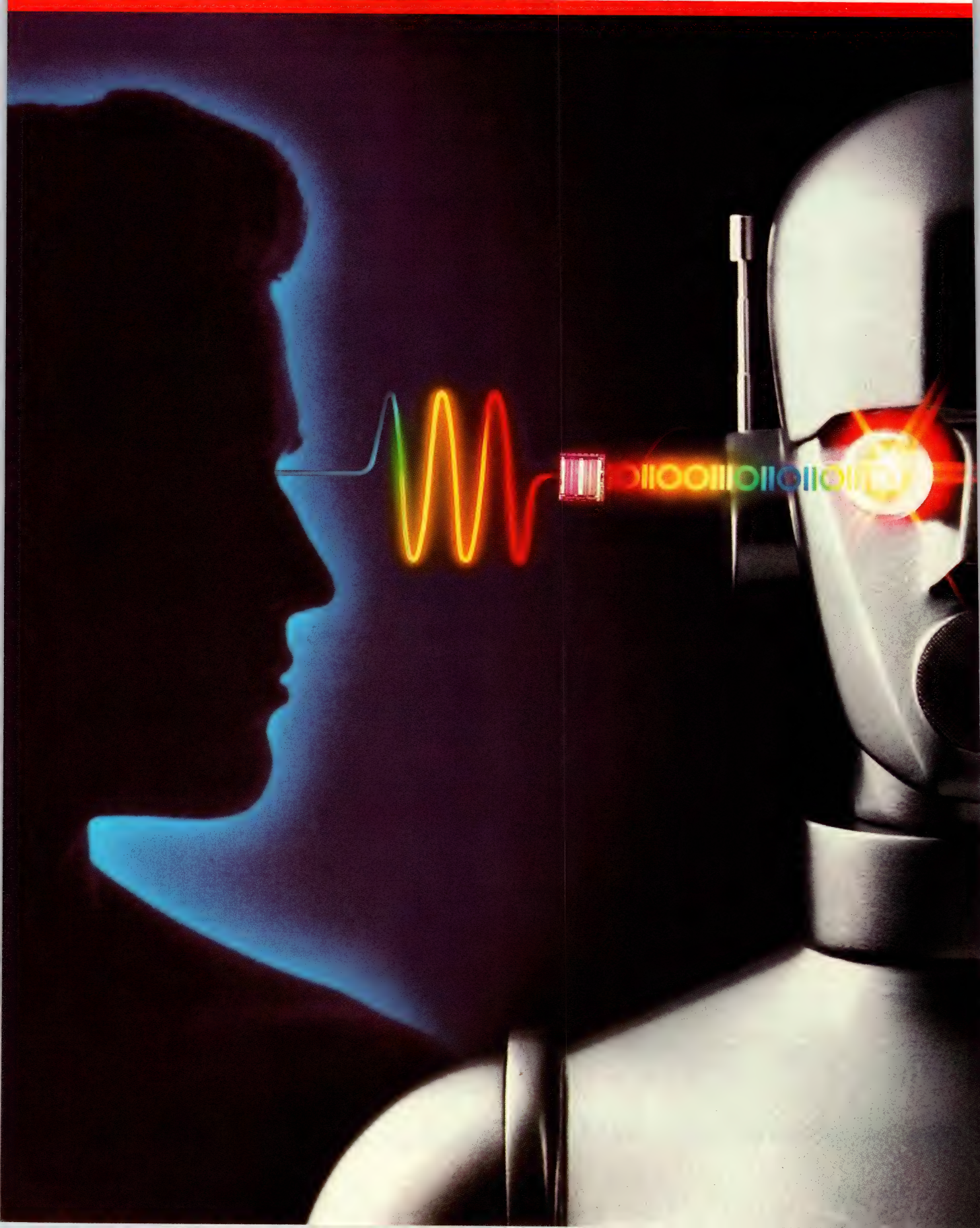
For your free copy of the new Rapid Systems catalog, to order, arrange a demonstration, or for further information, call or write Rapid Systems, 433 N. 34th St., Seattle, WA 98103. (206) 547-8311, Telex: 265017UR.

RAPID SYSTEMS



Changing the way we think about instruments.

High-resolution conversion



in the blink of an eye.

Get video speed, low power consumption, high resolution and superior price/performance with our new CMOS data converters.



We've expanded our line to include more CMOS flash ADC's, a charge balancing ADC, an SPI ADC and a DAC. All featuring single 5V supply operation.

We also offer a new high-speed op amp especially well-suited to driving ADC's or video cables.

4, 6 and 8-bit CMOS flash ADC's.

Choose from 4, 6 and 8-bit ADC's. All operate at video speeds, with clocking speed and input bandwidth specified at 5V. What makes these flash ADC's special is silicon-on-sapphire construction, resulting in low cost, high speed, very low input capacitance, low power consumption and inherent latch-up resistance.

10-bit CMOS charge balancing ADC.

This 10-bit successive approximation ADC captures fast moving signals, providing excellent resolution.

It features a built-in fast track and hold, with conversion rates of 150 KHz and an input bandwidth of 1.5 MHz. Even at the maximum rate, power consumption is less than 20 mW.

10-bit CMOS serial ADC.

The CDP68HC68A2 is selectable for either 8- or 10-bit resolution and has an 8-channel multiplexer allowing up to 8 channels of inputs. The device can be used directly with our CDP68HC05C4, C8 or D2 microprocessors or other similar SPI (Serial Peripheral Interface) buses.

8-bit CMOS R-2R video-speed DAC's.

These CMOS/SOS digital-to-analog converters operate

from a single 5V supply at video speeds and can produce "rail-to-rail" output swings. Typical update rate is 50 MHz. Settling is fast (20 ns typical) to 1/2 LSB. "Glitch" energy is minimized by segmenting and bar graph decoding of upper 3 bits.

High-speed op amp.

Specially designed for use with data converters, the CA3450 op amp has excellent speed and transmission line driving capabilities.

For 10-bit accuracy, it settles to within 1/2 LSB in 40 ns with a 2V input signal. And it can drive up to four 50 ohm transmission lines.

ADC's	Res. Bits	Conv. Rate Hz	Power Diss. (mW)	Pkg. Leads	1K Price
CA3304E	4	20M	30	16	2.95
CA3304AE	4	25M	35	16	4.50
CA3306CE	6	10M	65	18	5.50
CA3306E/3306AE	6	15M	70	18	6.25/11.25
CA3318E/3318CE	8	15M	150	24	38.50/24.00
CA3310E/3310AE	10	150K	15	24	6.00/8.00
CDP68HC68A2E	10	10K	15	16	3.75
DAC's					
CA3338E/3338AE	8	50M	100	16	6.00/8.40
OP AMP					
	UGBW Hz	Slew Rate (X10)	I _{out} MA	Pkg Leads	1K Price
CA3450E	200M	300V/μSec	±75	16	2.70

Data in a flash.

For data sheets of these new products, call toll-free 800-443-7364, extension 19. Or contact your local GE Solid State sales office or distributor.

In Europe, call: Brussels, (02) 246-21-11; Paris, (1) 39-46-57-99; London, (276) 68-59-11; Milano, (2) 82-291; Munich, (089) 63813-0; Stockholm (08) 793-9500.



GE Solid State

GE/RCA/Intersil Semiconductors

Three great brands. One leading-edge company.

EDN May 12, 1988

*Trademark of General Electric Company, U.S.A., not connected with the English Company of a similar name.

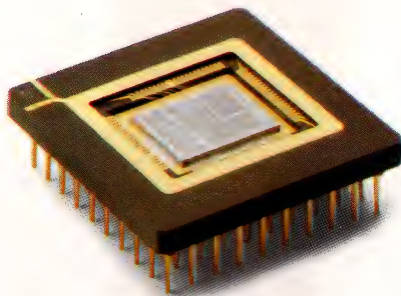
**"WITH THE EXCEPTION
OF OBSERVATION, I SEE NO
MILITARY USE FOR IT."**

AMERICAN GENERAL, 1908



"IT'S GOT POSSIBILITIES, BUT IT'S JUST TOO POWERFUL FOR MY APPLICATION NEEDS!"

DESIGN ENGINEER, 1988



Over the centuries, people have looked at the latest in technology with a bit of skepticism. The Transputer from INMOS is no exception.

When we first introduced the Transputer, designers were indeed intrigued. They were impressed with our T800—a 32-bit floating point microprocessor with an average speed of 10 MIPS and the ability to sustain 1.5 MFLOPS or 4.0 million single precision whetstones. "Incredible," designers said. "But it's more than we can use."

Not true. The fact is as a stand-alone processor, the T800 gives you benefits you can use every day. It runs programs even faster than Intel's combined 80386 and 80387 or Motorola's combined 68020 and 68881. Plus, it requires significantly less memory to hold compiled code.

And, by increasing the number of Transputers, you can increase system performance proportionally

with no limit to the number of Transputers that can operate concurrently. Like linking seven T800's together to give you the processing power of a mighty Cray T3E supercomputer.

Or you could use ten IBM add-in cards from INMOS carrying ten T800's each, to enable your desktop PC to deliver 150 MFLOPS. That's like having the power of 150 11/780 VAX machines right at your fingertips.

So take another look at the Transputer. It's not just a dream for the future, it's a high-performance product for today. And it's a technology that is already taking off.

TRANSPUTER



INMOS, Colorado Springs, Colorado 80935. Tel. 719-630-4000, Orange County 714-957-6018, Santa Clara 408-727-7771, Denver 303-252-4100, Minneapolis 612-932-7121, Dallas 214-490-9522, Boston 617-366-4020, Baltimore 301-995-6952, Atlanta 404-242-7444.

INMOS Transputer and IMS are trademarks of the INMOS Group of Companies. Motorola is a registered trademark of Motorola, Inc. Intel is a registered trademark of Intel Corporation. VAX is a registered trademark of Digital Equipment Corporation. Cray is a registered trademark of Cray Research, Inc. IBM is a registered trademark of International Business Machines Corp.

How to tame your power hog:

Spec-in Harris bipolar low-power op amps: power savings as good as CMOS op amps, AC like never before.

Portable systems designers: the compromising is over. O-V-E-R.

Now get the low-noise and high-speed performance you want — with the micropower consumption portable systems demand.

Low-power Harris op amps offer all the muscle of general-purpose amps, but only 1/30 the power use. (HA-514X series amps typically draw just 45 μ A per amplifier; new 515X amps only 200 μ A per amplifier.) No other op amp comes close to matching this combination.

They're available as singles (5141 or 5151), duals (5142 or 5152) or quads (5144 or 5154); in cans, plastic and ceramic DIPs, and leadless chip carriers (LCCs).

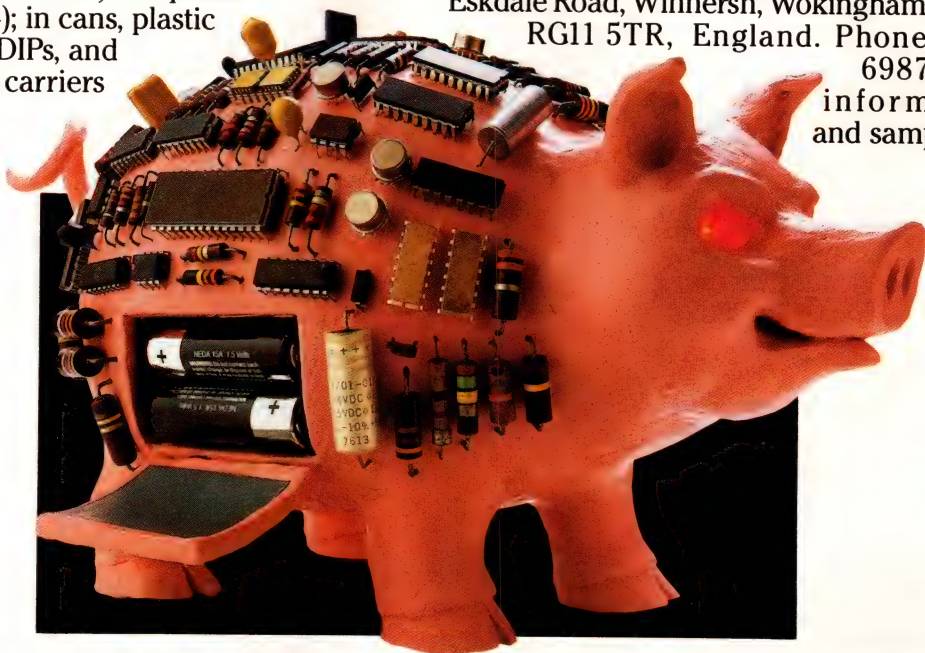
Choose MIL-STD-883, commercial or industrial grades. They offer the big-time performance and small power drain you covet for battery-powered systems...audio filtering, summing, amplifying, remote sensor/transmitters, and hundreds more.

With their single supply operation, these low-power bipolar amps mesh perfectly with our full line of static CMOS digital components.

Harris Micropower Op Amps

	5141/42/44	5151/52/54
Supply Current (μ A/Amp)	45	200
Gain Bandwidth (MHz)	0.4	1.3
Slew Rate (V/ μ s)	1.5	4.5

Call Harris Semiconductor Sales Ltd., Eskdale Road, Winnersh, Wokingham, Berks, RG11 5TR, England. Phone 0734-698787 for information and samples.



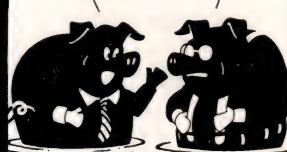
IN HIGH-SPEED OP AMPS,
THE NAME IS
HARRIS

Harris Semiconductor: Analog - CMOS Digital
Gallium Arsenide - Semicustom - Custom



"My designer wanted
to cut my appetite.
With Harris amps,
I'm cured!"

"Never say cured
to a hog."



Precision DACs enhance the stability of closed-loop designs

Closed-loop designs oftentimes require the use of D/A converters that have both monotonic response and data readback. This combination of capabilities is now available in off-the-shelf ICs, and thus you'll find it simpler to design stable control loops with 16 bits of resolution and monotonicity.

Damien McCartney and Mike Curtin,
Analog Devices, BV

Closed-loop designs require that the response of the control system be monotonic: For an increasing digital input code, the output voltage should never decrease and, preferably, it should always increase. Further, if the system operates in a noisy environment, or if it is located remotely from the master computer, there is the risk that invalid data may be written to the D/A converter controlling the loop. Data errors can have serious safety implications and cause loop instabilities.

Double-rank input registers with data-readback capability allow you to verify that a converter has received correct data before you update its output. Integrated D/A converters with guaranteed monotonicity—albeit often with limited resolution—have been available for years. Converters capable of

data readback have become available more recently. Now, devices that combine 16-bit resolution, guaranteed monotonicity, and readable double-rank registers are becoming available. One of these, a CMOS part with an unusual, voltage-segmented architecture, serves as a representative example and illustrates how you can advantageously use DACs such as these in your closed-loop designs.

The AD7846 (see **box**, "Voltage segmentation enhances DAC performance") inherently guarantees monotonicity. The device also incorporates a bidirectional input latch, so that you can both write data to and read data from the DAC's input. After verifying the data's validity, you can transfer the contents of the input latch to the secondary converter latch, updating the device's output.

End phantom memory

For instance, you can use the AD7846's monotonicity and readback function to enhance ATE system reliability. VLSI test systems can contain as many as 1000 D/A converters. Such testers need to run automatic diagnostic, calibration, and debugging routines to maintain reliable system performance. One debugging technique uses "phantom memory" to check if proper data has been written to the converter; the data in a phantom memory location should be the same as the data in the DAC's latch. Not only does this technique use $1k \times 16$ bits of RAM for 1000 converters, it doesn't guarantee that the data in a D/A converter is correct, especially if

Data errors can have serious safety implications and can cause loop instabilities.

the phantom memory is located at a distance from the D/A converters.

You can overcome both of these drawbacks by using a readback D/A converter. First, load the data word into the DAC's input latch. (On the AD7846 you use the $\overline{CS}$ and $R/\overline{W}$ control inputs.) Next, read the contents of the latch. (On the AD7846 you bring $\overline{CS}$ low and $R/\overline{W}$ high.) Once you've applied the control signals, complete the data transfer. (On the AD7846 you do it by bringing the asynchronous $\overline{LDAC}$ control line low.) The analog equivalent of the digital word will appear at the output of the converter.

Pin driver resolves 300 μV

If you're an ATE system designer, you'll recognize the circuit in **Fig 1**. It's a pin driver/receiver. Each pin on the device under test (DUT) may be a digital input or output. IC₁, an AD345, is the pin driver for the digital inputs, and IC₂, a dual high-speed comparator, is the

receiver for the digital outputs. The digital control circuitry determines the signal timing and format.

You set the pin-driver (V_H and V_L) and receiver voltage levels by programming the digital inputs to the DACs. The dc-parametric test routines close the loop by feeding back the pin voltage to the system controller. With 16-bit converters, you can use the D/A converters' resolution to compensate for input/output nonlinearities. Fine-tune the pin test voltage by incrementing or decrementing the converter inputs until you obtain the desired voltage. In a typical digital test system, the voltage span is -3 to $+10V$. Accordingly, configure the AD7846s for $\pm 10V$ operation. The resolution will correspond to 300 μV per LSB.

You can employ a high-precision reference for each pin-driver circuit. The circuit of **Fig 1** uses an AD588, IC₃, to generate a $\pm 5V$ tracking reference for the V_{REF+} and V_{REF-} of the AD7846s. Internal circuitry in the D/A converter scales the reference input to produce an

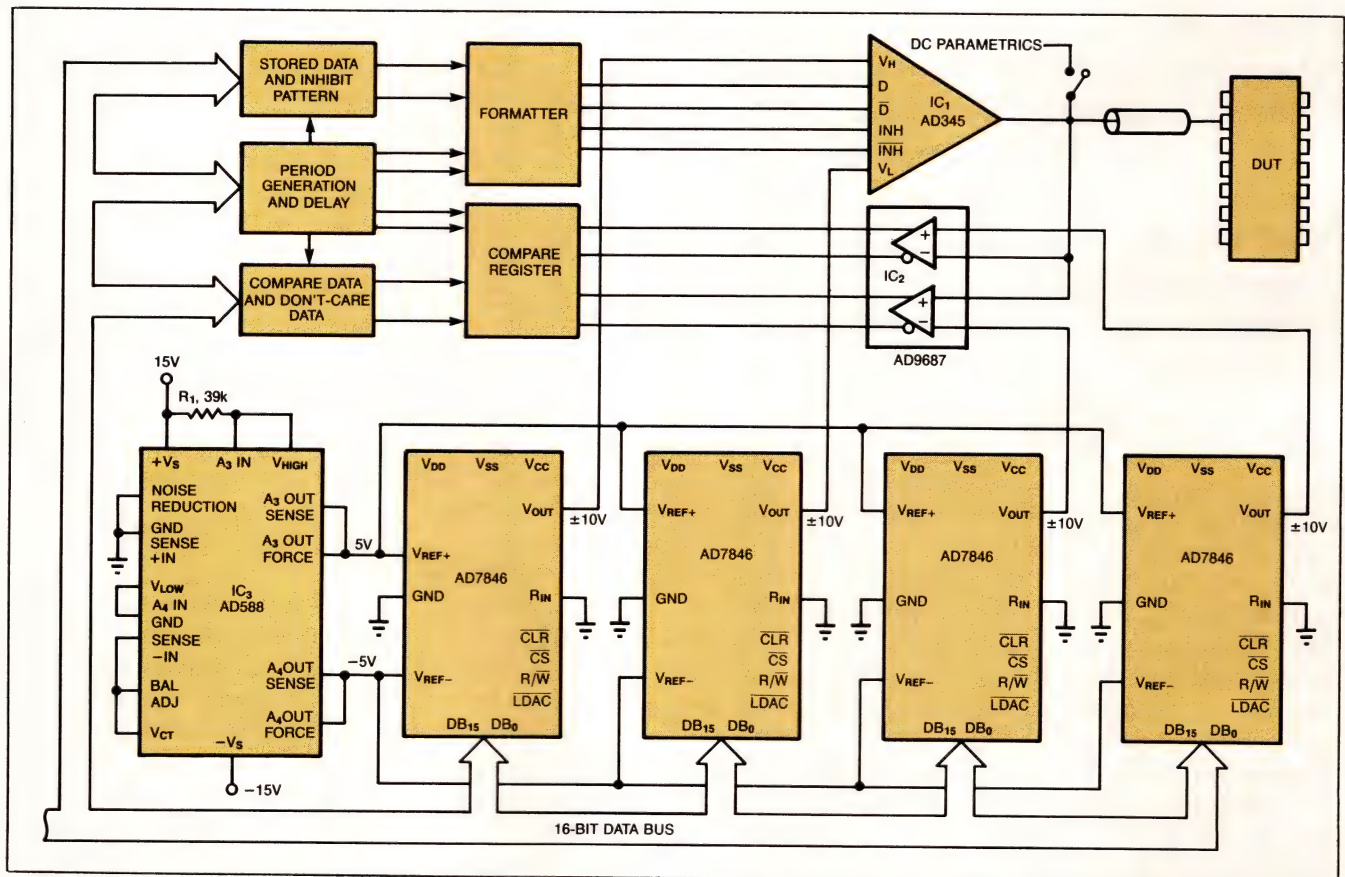


Fig 1—Pin-driver/receiver circuits for VLSI test systems require numerous high-resolution D/A converters, as you can see. The four AD7846 D/A converters set the high and low logic levels for the AD345 pin driver and the AD9687 receiver. During a calibration cycle, the system controller can both write and read data from the converters' latches, eliminating the need for phantom memory.

Voltage segmentation enhances DAC performance

The AD7846 DAC, from Analog Devices (Norwood, MA), achieves ± 1 -LSB differential linearity error and better than ± 2 -LSB integral nonlinearity. In addition to a 16-bit CMOS D/A converter, the IC incorporates a number of bipolar amplifiers, including an output buffer. All you need to do is supply a external reference voltage. The IC fits in a small 28-pin dual-in-line or surface-mount package.

At the heart of the AD7846 (Fig A) is a voltage-segmented D/A converter. It actually comprises three D/A converters, each with its own buffer amplifier. Two 4-bit D/A converters, DAC₁ and DAC₂, share a 16-resistor string, but have their own analog multiplexers. (You apply the external reference voltage to this resistor string.) Another 12-bit R/2R D/A converter, DAC₃, operates in the voltage mode.

The 4 most significant bits of the 16-bit digital code drive DAC₁ and DAC₂; the 12 least significant bits control DAC₃. The MSBs select a pair of adjacent nodes on the resistor string and present the generated voltage to the positive and negative inputs of DAC₃. DAC₃ then interpolates between these two voltages to produce an analog output voltage. Because the voltages at successive nodes on the resistor string are always higher than those at the preceding node, the voltage applied to DAC₃ will always be positive. Furthermore, if the DAC₃ is monotonic, the overall converter will also be monotonic. (It is much easier to build a monotonic 12-bit R/2R D/A converter than it is to build a 16-bit one.)

The design of the AD7846 also compensates for the nonideal behavior of the amplifiers. Consider an 8FFFH to 9000H transition with an applied reference of

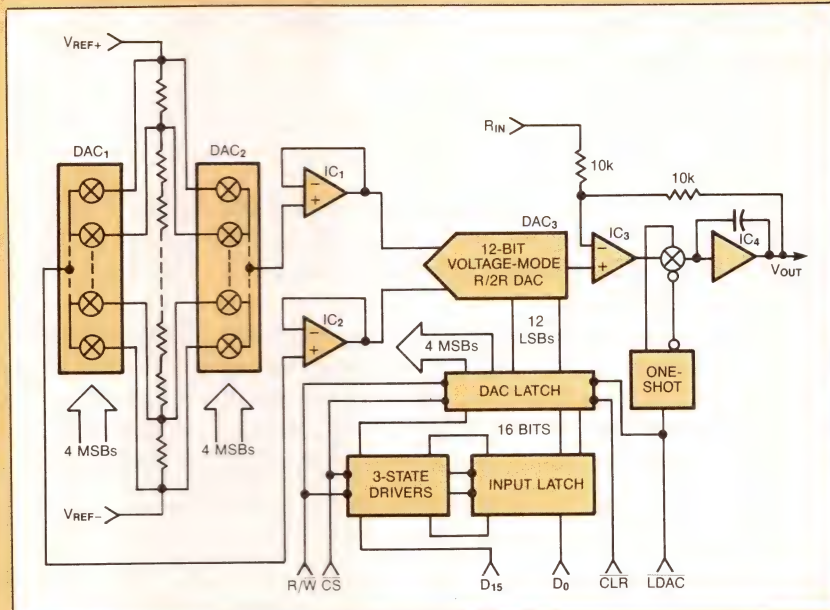


Fig A—This voltage-segmented D/A converter employs three internal D/A circuits and buffer amplifiers to ensure monotonic operation. The fast bipolar amplifiers deliver a settling time of 7 μ sec to $\frac{1}{2}$ LSB.

± 5 V. At the former code, DAC₁ generates 0V and DAC₂ produces 0.625V. DAC₃, therefore, will generate a 0.624847V output. At 9000H, DAC₁ changes its output to 0.625V and DAC₂ switches to 1.25V. DAC₃, receiving a zero code, will produce a 0.625V output. If DAC₁'s amplifier has a -1 -mV offset, however, the generated voltage will decrease to 0.624V, a nonmonotonic response.

To prevent offsets from influencing monotonicity, DAC₂ remains at 0.625V while DAC₁ "leapfrogs" from 0 to 1.25V. At the same time, the input code to DAC₃ is complemented. Now, offset in the amplifiers won't cause nonmonotonicity, because the outputs at both 8FFFH and 9000H are determined principally by the output of DAC₂, which doesn't change between the two adjacent codes. This scheme actually simplifies the multiplexers in DAC₁ and DAC₂ because the former has the even nodes as inputs, and the latter operates from the odd-numbered nodes.

Other useful features on the

AD7846, some of which are central to the accompanying article, are fast JFET amplifiers, a resistor feedback network, a track-and-hold amplifier, double-rank input registers whose outer rank can be read back, and a reset input. On a full-scale output swing of -10 to $+10$ V, the D/A converter settles to within $\frac{1}{2}$ LSB in 7 μ sec. You can configure the internal feedback network for gains of 1 or 2; with a ± 5 V reference, the AD7846 generates a ± 5 or ± 10 V output. The addition of a track-and-hold amp to the output buffer amplifier reduces glitches at major code transitions, making the AD7846 useful in audio reconstruction and waveform generation. You can reset the D/A converter's output by selecting the $\overline{\text{CLR}}$ and $\text{R}/\overline{\text{W}}$ pin. Strobing to the $\overline{\text{CLR}}$ terminal with the $\text{R}/\overline{\text{W}}$ pin low resets the output to 0V if you configure the converter for unipolar operation; strobing the $\overline{\text{CLR}}$ terminal with the $\text{R}/\overline{\text{W}}$ pin high resets the output to 0V if you're using a bipolar output range.

Double-rank input registers with data-readback capabilities allow you to verify that a converter has received correct data before you update its output.

output of $\pm 10V$. The impedance seen looking into the DAC's reference terminals is typically $30\text{ k}\Omega$, so the AD588's internal buffer amplifiers supply a total of 1.3 mA to the four DACs.

If your circuit board exhibits a large amount of trace resistance, you may encounter small voltage drops at the reference inputs of the converters, resulting in small gain and offset errors. You may want to compensate for these errors through a software calibration

cycle. However, if you need very high accuracy, you should buffer the reference inputs of each of the four AD7486s with separate amplifiers.

Program dynamic loads

You can expand the capabilities of your test system by adding a dynamic load. The circuit in Fig 2, though similar to that of Fig 1, includes three additional D/A converters embodied in two IC packages. The AD7547,

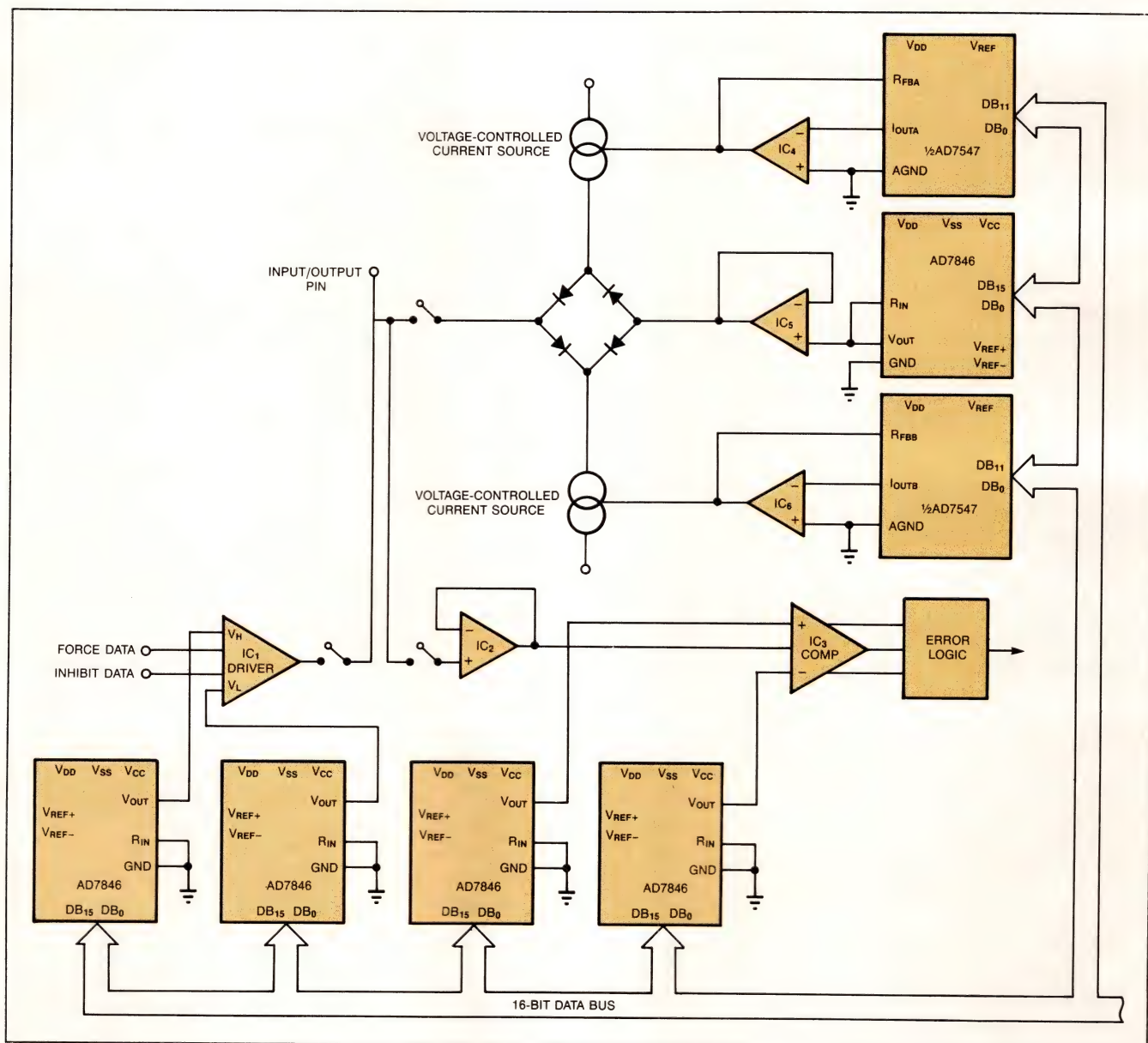


Fig 2—A complete circuit for testing digital logic needs dynamic-load capabilities. A dual 12-bit DAC and an AD7846 16-bit DAC control the sink and source current to stress the digital output of the device under test.

a dual 12-bit D/A converter, controls the current-source and current-sink setup to stress the digital output of the DUT. The additional AD7846 sets the threshold logic level. If you're testing a TTL output, set the current source to 1.6 mA and the current sink to 400 μ A. For an ECL output, you'll need the current sink set to two different values: 20 mA for the V_{OL} level, and 7 mA for the V_{OH} . Configure the AD7846 for bipolar operation so that, when testing a TTL output, you'll be

able to set the crossover point between V_{OH} and V_{OL} at 1.6V. (With an ECL output, use $-1.3V$.) You can use the same reference-driving circuitry for this circuit as that of Fig 1.

RTD simulator mimics changing temperature

Many closed-loop temperature-control systems use resistance temperature detectors (RTDs). Commonly made from platinum, they operate over the -150 to $+600^{\circ}C$ temperature range, which makes them ideal for industrial applications. Most RTDs are configured with four terminals (Fig 3). The current source forces a "known" current into the transducer, and two sense wires monitor the voltage drop across the RTD. Because the digital voltmeter has a high input impedance, the generated voltage at the input terminals of the meter is proportional to the resistance of the sensor.

You can build a portable battery-powered RTD simulator to test and calibrate the accuracy of any RTD-based temperature-monitoring system you might have. With the simulator, you can calibrate a system without bringing the controlled processes to their operating temperatures. In addition, the simulation of alarm conditions can test your control system's response to dangerous fault conditions. The circuit in Fig 4 uses an AD7846 to accurately simulate an RTD. In this case, the 16-bit D/A converter generates calibration signals

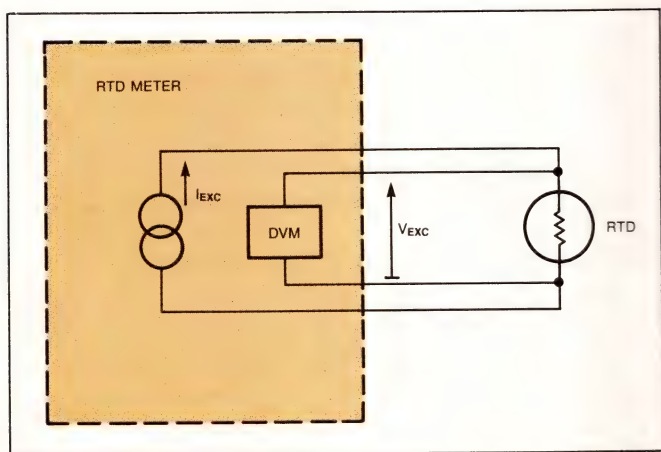


Fig 3—RTDs use a 4-wire configuration to force a current through the sensor and monitor the corresponding voltage drop. Once calibrated, the RTD can offer high measurement accuracies over a wide temperature range.

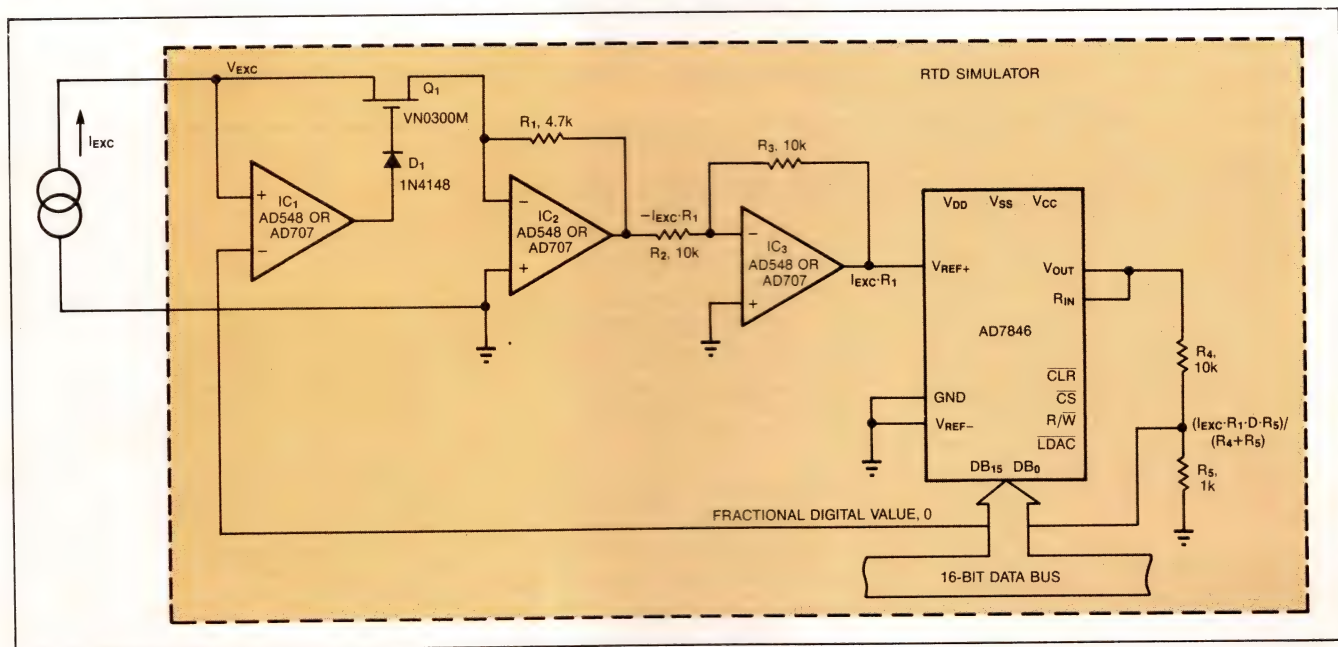


Fig 4—You can use a battery-powered RTD simulator for field calibration of temperature-measurement systems. This circuit can accurately simulate RTDs with a temperature resolution and accuracy better than $0.1^{\circ}C$.

You can build a portable battery-powered RTD simulator to test and calibrate the accuracy of any RTD-based temperature-monitoring system you might have.

that simulate RTD outputs with an accuracy of better than 0.1°C. Furthermore, the low power dissipation (250 mW if you use low-power amplifiers such as the AD548) extends the battery life of handheld calibration meters.

Amplifier IC₁ drives the n-channel MOSFET, Q₁, so that V_{EXC}, the excitation voltage, is equal to the voltage on the amplifier's inverting terminal. Install diode D₁ to prevent any negative excursions at the gate of the MOSFET. Resistor R₁ mirrors the constant current, I_{EXC}, from the RTD, setting up a voltage (–I_{EXC}·R₁) at the output of amplifier IC₂. Resistors R₂ and R₃ and amplifier IC₃ invert this voltage to supply a reference of (I_{EXC}·R₁) at the V_{REF+} input of the AD7846. The D/A converter's output voltage is D·I_{EXC}·R₁, where D is the fractional code applied to the converter. Resistors R₄ and R₅ feed back a portion of this signal to the inverting input of IC₁ to complete the loop. Therefore,

$$V_{EXC} = I_{EXC} \cdot R_1 \cdot D \cdot \frac{R_5}{R_4 + R_5}.$$

The simulated RTD resistance is

$$R_T = \frac{V_{EXC}}{I_{EXC}} = R_1 \cdot D \cdot \frac{R_5}{R_4 + R_5}.$$

In practice, you should limit I_{EXC} to 2 mA to minimize the self-heating effects in the RTD. Use a 4.7-kΩ resistor for R₁ to program a V_{REF+} of approximately

10V maximum at the AD7846's input. Fig 4's R₄ and R₅ values permit you to simulate an RTD range from 427 to 1Ω; the R_{ON} of the MOSFET determines the 1Ω minimum. You can easily change the resistance range, however, by varying the ratio of resistors R₄ and R₅.

If you use low input-offset-voltage amplifiers in this circuit (AD707s, for example), then offset calibration isn't necessary. You might, however, still have to reduce gain errors due to resistor tolerance and mismatch. If you replace R₃ with a 9.1-kΩ resistor in series with a 2-kΩ potentiometer, you can perform a hardware gain adjustment. Alternatively, if the D/A converter is microprocessor controlled, you can include a gain factor in the RTD simulation algorithm. This simulation algorithm can also compensate for RTD nonlinearities (see **box**, "Callendar-Van Dusen equation describes RTDs").

Motor control positions to 2 arc-minutes

You can build a high-accuracy closed loop positioning system by combining the AD7846 with a 16-bit resolver-to-digital converter. The monolithic R/D converter in Fig 5 has a programmable resolution of 10, 12, 14, or 16 bits, and accuracy options of 2, 4, or 8 arc-minutes. The 2S80 accepts a sine and cosine signal from the resolver and converts it into a 16-bit word. A Busy signal informs the microprocessor when the output data is valid. The μP reads the information into its accumulator by selecting the Enable and Inhibit pins on the 2S80.

Because the AD7846 is monotonic at the 16-bit level,

Callendar-Van Dusen equation describes RTDs

RTDs are not perfectly linear devices, but you can characterize them with the Callendar-Van Dusen equation. RTD meters can use the equation to linearize RTD-resistance variations over temperature, or you can use the equation to shape the linear D/A-converter response to fit the characteristic RTD curve:

$$R_T = R_0 + R_0 \left[T - \delta \left(\frac{T}{100} - 1 \right) \left(\frac{T}{100} \right) - \beta \left(\frac{T}{100} - 1 \right) \left(\frac{T^3}{100} \right) \right],$$

where R_T=resistance at temperature T, R₀=resistance at T=0°C, α=temperature coefficient at T=0°C (0.385Ω/°C for 100Ω platinum RTD), δ=1.49 (typical value for platinum), β=0 at T≥0°C, and β=0.11 (typ) at T<0.

You can check the accuracy of the circuit in Fig 3 of the accompanying article by simulating a PT100 RTD. This platinum RTD with an R₀ (resistance at 0°C) equal to 100Ω has a temperature coefficient of 0.385Ω/°C. Thus,

its resistance ranges from 120Ω at 50°C to 290Ω at 500 °C.

Using hardware gain calibration and the Callendar-Van Dusen equation for curve fitting, you can simulate the RTD's resistance with an absolute accuracy better than 30 MΩ over the full operating temperature range. This error corresponds to a temperature accuracy of better than 0.1°C.

Analog CAE is More Than SPICE.

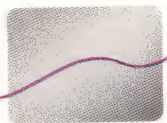
It's the ability to predict manufacturing yields, find stressed components, and pick devices from libraries containing over 1,200 simple and complex devices. It gives you software-based instruments that act

just like the instruments in your lab—except they make measurements that would be impossible with normal lab equipment.

Analog CAE is now all of this, and more—thanks to the Circuit Design Tool Kit and the popular Analog Workbench™ and PC Workbench™ software. All are designed to work with a variety of CAE and CAD systems, simulators and models (including your own), and remote computers.

Why settle for SPICE alone when you can have a complete set of the most advanced design tools made today? See the latest in analog CAE for yourself: call 1-800-ANALOG-4, ask for a FREE Demo Disk or Video.

CIRCLE NO 67

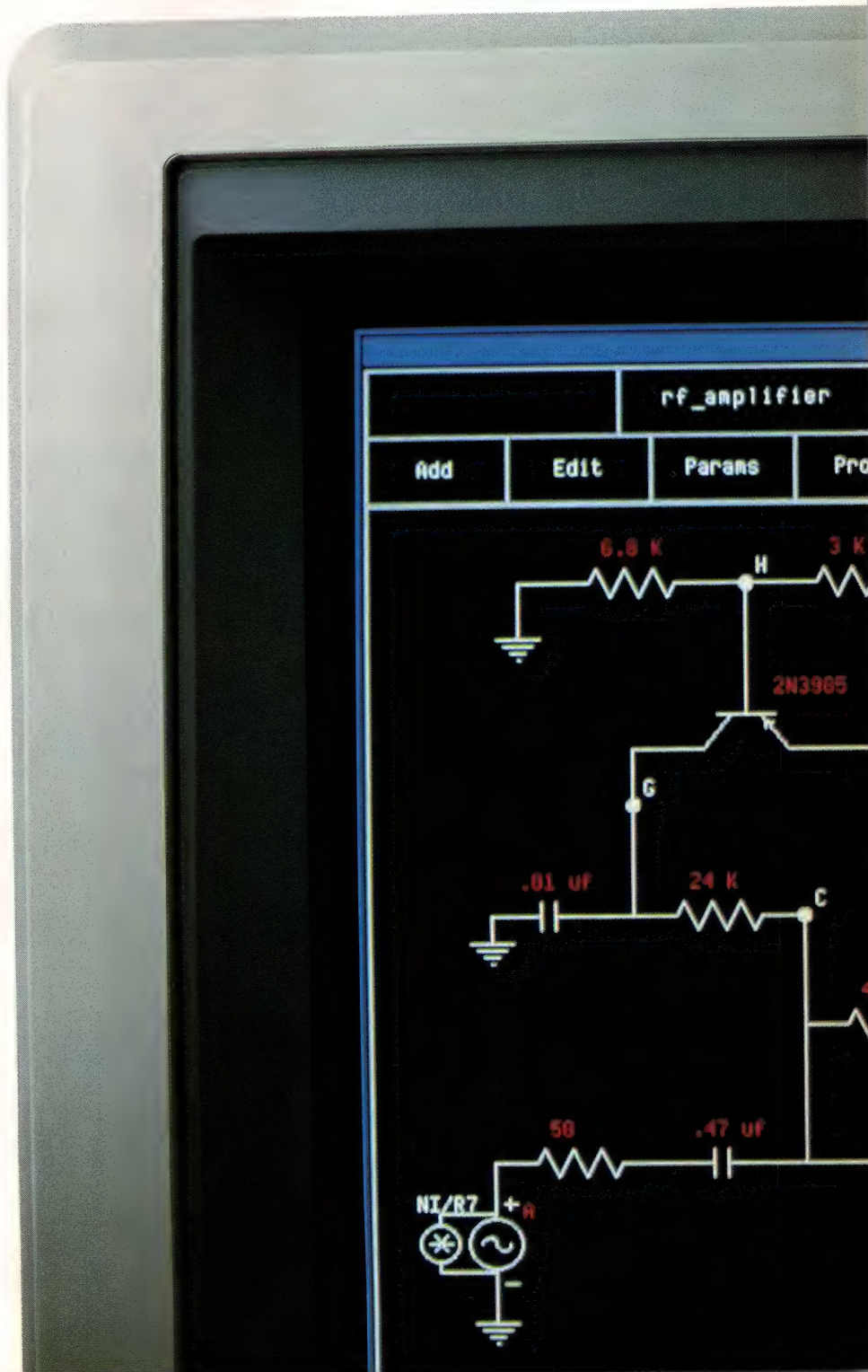


ANALOG
DESIGN
TOOLS

See Us At DAC Booth 1304

1080 East Arques Avenue
Sunnyvale, CA 94086
408-737-7300 or 1-800-ANALOG-4

© 1987 Analog Design Tools, Inc.
Analog Workbench and PC Workbench are
trademarks of Analog Design Tools.



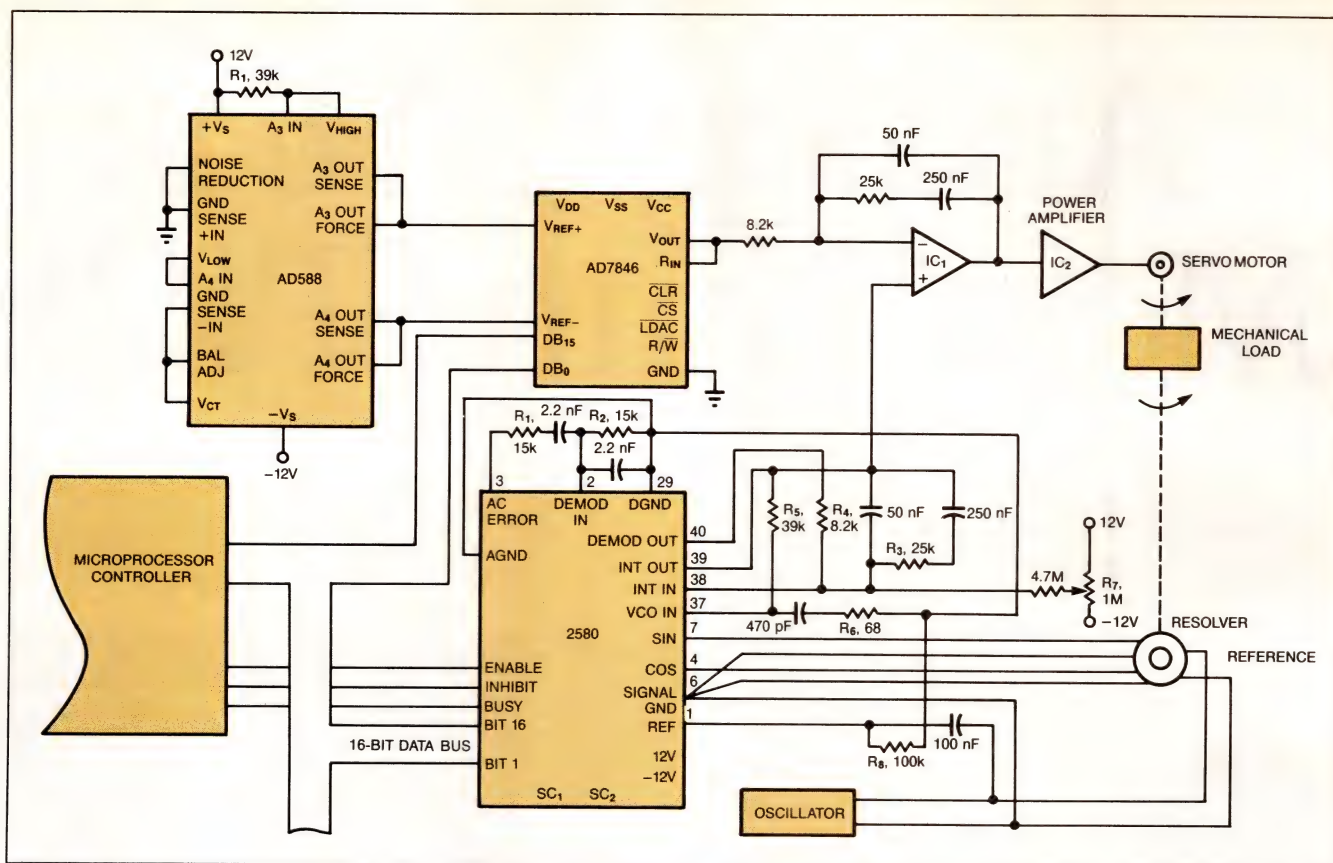


Fig 5—This closed-loop positioning system has no loop instabilities and can position a load to an accuracy of less than 2 arc-minutes. The 2S80 resolver-to-digital converter IC provides an analog output proportional to velocity for tight speed control of a motor.

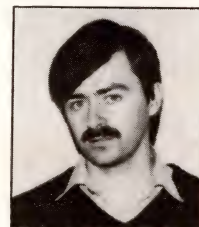
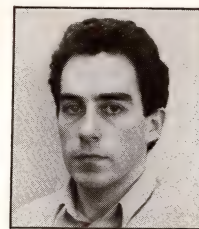
you can theoretically drive the motor in Fig 5 to within 1 LSB of the desired position. In practice, the feedback element, the 2S80 in this circuit, will restrict the overall accuracy. The top grade of the 2S80 has an absolute accuracy of ± 2 arc-minutes +1 LSB.

You program the microprocessor with the desired motor position. Until the desired and actual positions are equal, the processor will generate an error signal for the D/A converter, which, in turn, drives the motor in the proper direction through a standard control circuit implemented by IC₁, power amplifier IC₂, and associated circuitry. The error signal becomes progressively smaller until the desired motor position is finally reached. Both the 2S80 and AD7846 are 16-bit monotonic, making the loop inherently stable. Furthermore, the signal at the integrator output of the 2S80 relative to AGND is an analog voltage proportional to the rate of change of the input angle. You can use this velocity signal to provide velocity stabilization of the servo loops without having to add an expensive electromechanical tachometer. Configured for 16-bit resolution, the R/D converter's maximum tracking rate is 16.25 rps.

error by adjusting potentiometer R₇. You can operate the motor in a bidirectional mode by configuring the AD7846 for a $\pm 5V$ output. The AD588 provides the $\pm 5V$ tracking reference. **EDN**

Authors' biographies

Damien McCartney is a senior design engineer at Analog Devices' CMOS Division in Limerick, Ireland, where he designs and develops DAC products. He has worked there for 3½ years. Prior to that, he worked for Centronics in both the US and Ireland. He holds a BE from University College in Dublin and an MSEE from Northeastern University in Boston. Damien is a member of both the IEEE and its English cousin, the IEE. In his spare time, he runs, swims, and reads.



LANCE NEIBAUER AND JOHN MARCONI. NEW ACHIEVERS IN SCIENCE.



we never stop asking

"What if..."

Lance Neibauer. Aircraft designer. His award-winning Lancair kitplanes are the nation's top-selling homebuilts. Now using the new HP-28S, the only calculator that can do symbolic algebra and calculus, retrieve and combine graphs instantly. HP Solve lets him enter his own formulas. More than 1500 functions and 32K bytes of RAM make it the world's most powerful scientific calculator. John Marconi. Air pollution control engineer. Project leader for study on cancer-causing air pollutants. Needs to solve statistical and financial problems.

Innovation takes a calculator packed with new ideas. Perfect job for the new HP-27S. It's the only scientific calculator with business functions. It also

offers easy-to-follow menus and optional solutions books. Hewlett-Packard's new range of calculators is built for your success. For the name of your nearest Hewlett-Packard dealer, call 1-800-752-0900, Ext. 215P

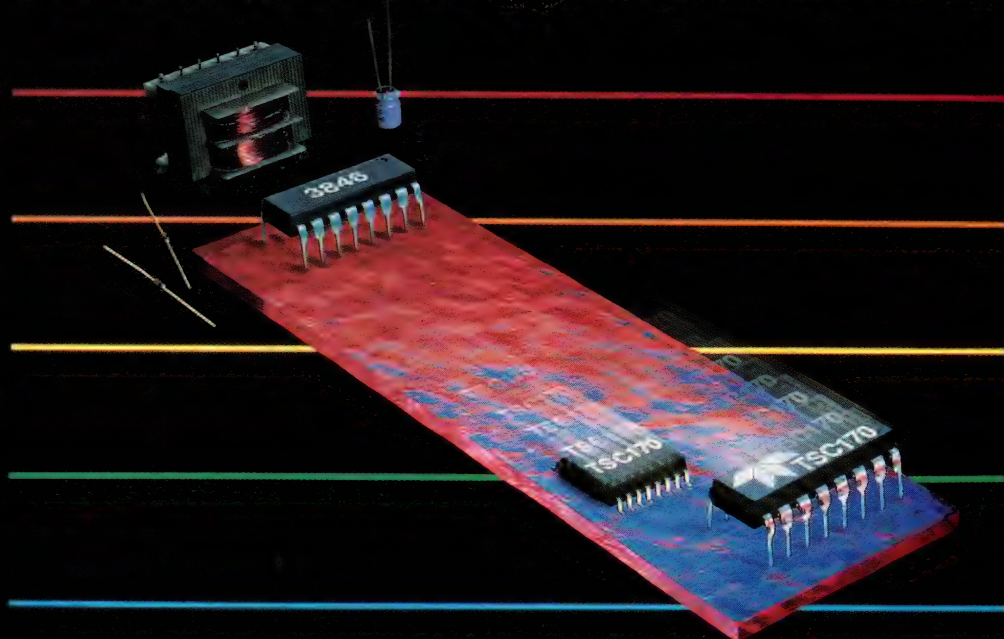


NEW ACHIEVERS: THE HP-28S AND HP-27S SCIENTIFIC CALCULATORS.



**HEWLETT
PACKARD**

One-fifth the power makes for one cool breakthrough in SMPS controllers



Announcing the world's first current mode switching power supply controller in cool-running CMOS.

The new **TSC170** is the first of its breed. A current mode switching power supply controller in CMOS, not bipolar.

Why CMOS? Because the **TSC170** uses just one-fifth the power of its pin-for-pin bipolar equivalent, the UC3846—2.7mA versus 17mA. It ends heat sinking at high temperatures. With no compromise in performance.

The **TSC170** makes your whole design run cooler—or lots cooler depending on your application. It lets you eliminate transformers and power resistors. It gives you 25% higher output drive current capability.

And Teledyne Semiconductor backs the **TSC170's** performance by guaranteeing start-up and drop-out points so you can predict how it will work in your application. Bipolar controllers don't.

Choose from three 16-pin package styles—**plastic DIP**, **CerDIP** or space-saving **SO surface mount**.

Like all our cool-running CMOS ICs, the **TSC170** comes with Teledyne's impeccable reputation for quality, service and support, earned over more than a quarter century in the semiconductor business.

Get the full story. Call today for a data sheet. Or ask for our Technical Hotline and one of our applications engineers will be glad to tell you more.

	CMOS TSC170	Bipolar 3846
Supply Current	2.7 mA	17 mA
Start-up threshold	7.25 to 8.25 V	8 V max
Threshold hysteresis	0.5 to 1V	0.75 V typ only
Max rise, fall time	150 ns	300 ns

 **TELEDYNE
SEMICONDUCTOR**

1-800-888-9966

415/968-9241

1300 Terra Bella Avenue
PO Box 7267
Mountain View, CA 94039
TWX 910-379-6494
FAX 415-967-1590

DC to DC Power Simply

Have you ever been disappointed in switched capacitor, high voltage DC to DC converter output current capability? The **CMOS TSC962** will look like it was designed just for you.

Low output resistance improves voltage transfer efficiency and increases current output. We guarantee a low 35Ω maximum output resistance for an 80mA output current. **THREE TIMES BETTER** than existing parts. Input voltage range extends from 3V to 18V. CMOS technology keeps quiescent current to just $510\mu\text{A}$.

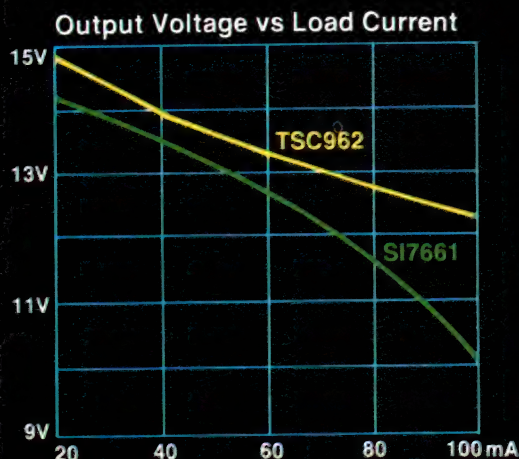
Only two external capacitors are needed for a complete positive to negative converter. By using the unique **FREQUENCY DOUBLER** pin, even the capacitors size can be reduced. Plus an on chip 6.4V zener for regulation applications.

More power, more functions and pin compatible to the SI7661, ICL7662, LTC1044 and ICL7660 parts. The TSC962 can be the standard DC to DC converter in your existing products and make your future designs easier.

Call or write for full information, design help and data sheets. Samples and production volume available now for you.

All devices are backed by Teledyne's reputation for quality, service and support — a reputation earned through 25 leadership years in the semiconductor industry.

Choose Teledyne First!



800-888-9966
415-968-9241

1300 Terra Bella Avenue
Mountain View, CA 94039
TWX: 910-379-6494
FAX: 415-967-1590
CIRCLE NO 69

 **TELEDYNE**
SEMICONDUCTOR

NDK: When timing is critical, rely on the leader



Clock frequencies from 28 kHz to 70 MHz. Only from NDK

Tiny tornado. NDK's 1300 Series Compact Crystal Clock Oscillators pack up to 70 MHz in a package 0.52" on a side. That means you can pack higher frequency oscillators on a smaller board. They're perfect for high speed applications such as modems, computers and CAD/CAM workstations. And the 1300 Series offers the widest range of TTL and CMOS-



Actual Size: 0.52" square. Less real estate. Full frequency range.

compatible oscillators you'll find. Enable/disable is standard. Dual frequency output is an option.

Think Small. These half-size clock oscillators are ideal for rugged, high density board applications. Particularly portable

CIRCLE NO 70

instruments, PCs and "harsh environment" applications.

Absolute quality control. Because we're the world's largest manufacturer of synthetic quartz crystals, we can establish and maintain absolute quality control. NDK unconditionally guarantees all of our crystal products to be free of impurities and defects. Thus, you can expect not only longer product life, but absolutely accurate frequencies over the full NDK product spectrum.



NDK 1300 Series: Broadest range of frequencies — 28 kHz to 70 MHz. Low power/low heat CMOS. Choice of TTL, CMOS or dual-compatibility. Rise and fall times (5, 7, 10 ns). Fan out (2 or 5 TTL gates). Sealed, grounded metal case is ideal for harsh environments.

NDK: Your single source. NDK offers the widest range of compact crystal

NDK controls every step from growing our own crystals, to manufacture and testing. That's why you can rely on NDK.

clock oscillators, microprocessor quartz crystals, standard crystal clock oscillators and crystal filters available. And most

products are available right off the shelf from NDK's nationwide network of stocking distributors

Free catalog. Free samples. Contact us for our free catalog. And if you're designing or prototyping a system, ask for free evaluation samples. We'll get back with samples.

Fast. Because at NDK, timing is everything.

NDK America, Inc.

20300 Stevens Creek Blvd., Suite 400
Cupertino, California 95014-2210
Telephone: (408) 255-0831
Telex: 352057 NDKCOLTD CPTO
Fax: (408) 725-0369



Microcontrollers simplify the design of X-Y plotters

Modern μ controllers have reduced the amount of circuitry needed for a plotter controller to a single chip and a few motor-drive components. Interrupt-handling features can provide aid when you're developing the control firmware.

Marc Birnkrant and Steve Beckwith,
NEC Electronics Inc

The μ controllers available today have so many on-chip features that control tasks have largely become a feat of software. Many of these devices have sufficient memory space, along with USARTs, interval timers, A/D converters, and multiple I/O ports, to handle control tasks that once would have required an entire CPU board. Microcontrollers with on-chip features such as these are well suited to the task of controlling an X-Y plotter.

Any X-Y plotter design requires two stepper motors. One motor drives a track feeder to move the paper along the Y axis, and the other motor drives a belt, with a pen attached, along the X axis. A solenoid controls the position of the pen. When you drive the solenoid, the resulting magnetic field produces a force sufficient for the pen to make contact with the paper. A limit switch senses when the position of the X-axis motor exceeds the plotter width.

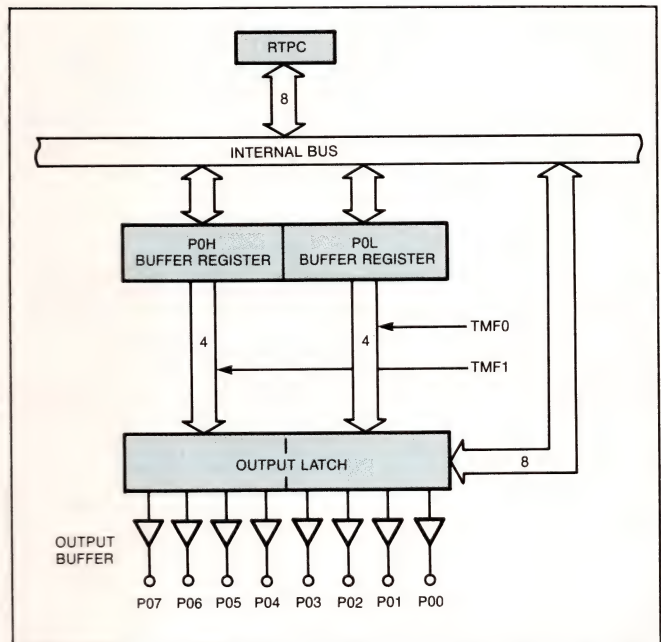


Fig 1—The real-time output port on the μ PD78312 μ controller eliminates the need for external latches.

In order to perform these real-time control tasks, the plotter has to be able to interpret data from two control sources. One source is a matrix keyboard, usually located on the front panel of the plotter. Using such a keyboard, you manually transmit setup parameters and pen-position information to the plotter. Plot scaling, drawing speed, and paper size are typical examples of setup parameters.

To perform the real-time control tasks, the plotter has to be able to interpret data from two control sources.

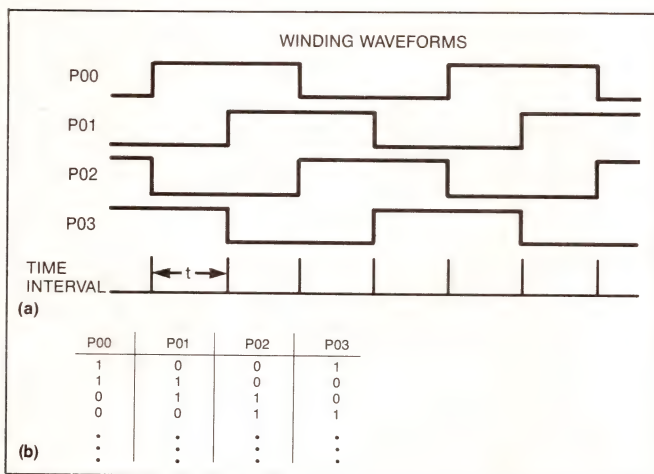


Fig 2—To control the speed of the stepper motor, you sequentially alter the time between phase changes of the stator windings.

A serial-communication link, which connects the plotter to a computer, provides the other control source. A USART provides the handshake lines necessary for communications. This link can transmit the data to be plotted as well as setup parameters. The μ controller interprets the data stream and positions the pen to automatically create the drawing.

Features aid in real-time control

Not surprisingly, many μ controllers are available that possess the features necessary to handle all of these control tasks. In fact, some μ controllers have features optimized for the real-time control tasks: overseeing the X- and Y-axis motors, governing the solenoid (and therefore the pen), and sensing the width of the paper.

NEC's μ PD78312 μ controller, for example, contains

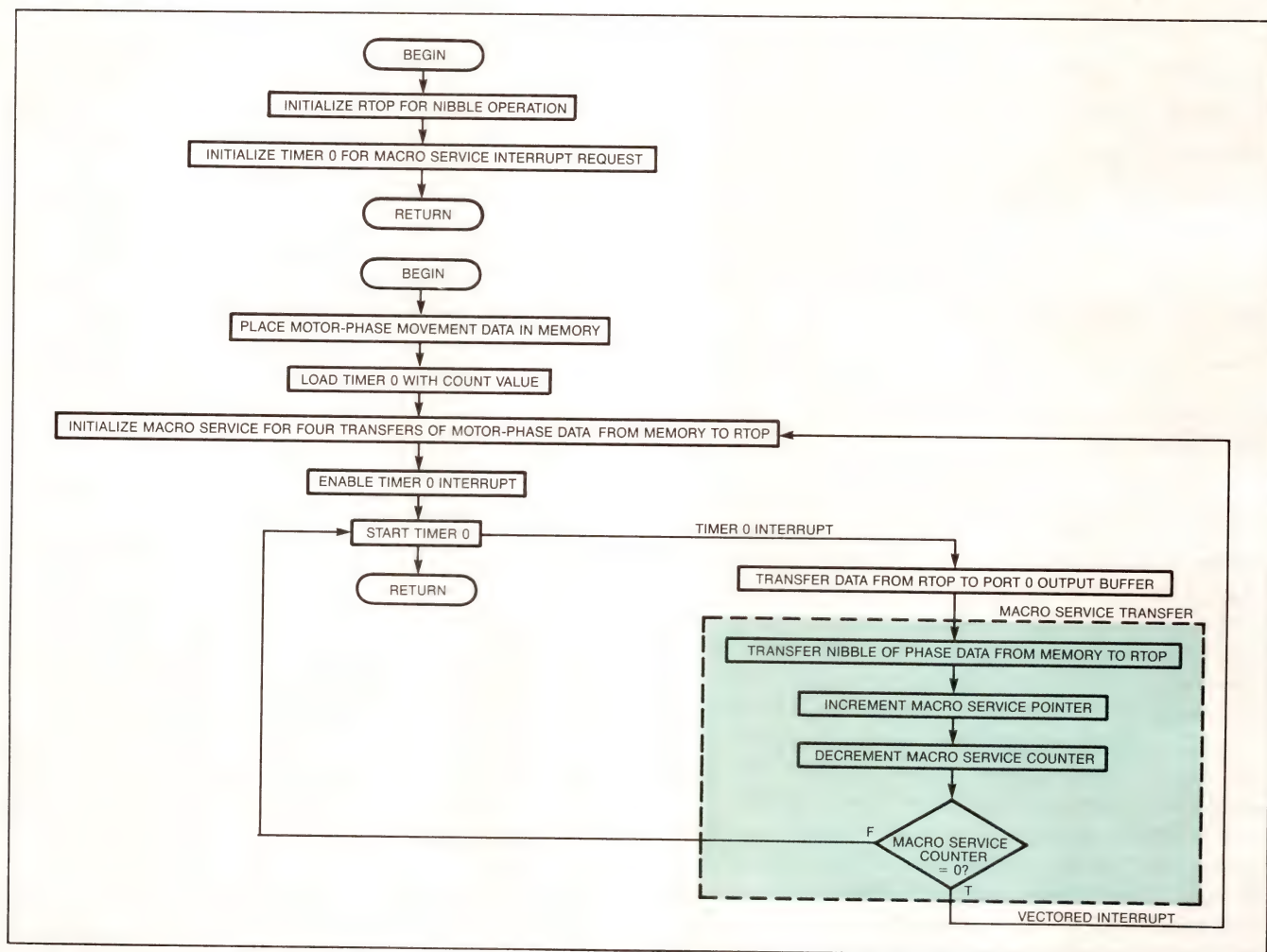


Fig 3—The Macro Service Transfer feature sends the phase data to the stepper motor with minimum CPU intervention.

a real-time output port (RTOP) that is well suited to the control of the two stepper motors. The RTOP consists of two 4-bit buffer registers (POH and POL), an 8-bit real-time port control register (RTPC), and an output latch for port 0 (Fig 1). Two on-chip programmable 16-bit timers (timer 0 and timer 1) set interrupt-request flags (TMF0 and TMF1) to transfer the data in the buffer registers to the output latch.

To see how to use the RTOP to control the motors, consider the typical waveforms for the stator windings of a 2-phase stepper motor (Fig 2a). You must ensure that the firmware first determines in which direction to step the motors and that it then stores four data words into memory as a table (Fig 2b). The words, which contain the phase data for each of the windings, are sequentially sent to the RTOP to drive the motors in the desired direction. (To reverse the motor direction, you must reverse the word sequence.)

The time interval, t , fixes the time between phase changes and, subsequently, the motor speed. To control one of the motors, you program timer 0 to set the TMF0 flag at the end of the time interval. The TMF0 flag initializes the transfer of data from the low nibble of the RTOP (POL) to the low nibble of the output latch at Port 0. Similarly, to control the time interval of the other motor, you program timer 1. The TMF1 flag initializes the transfer of data from the upper nibble of the RTOP (POH) to the upper nibble of the output latch at Port 0. Immediately following a data transfer to the output latch, the firmware loads the buffer registers with data from the memory table for the next step in the sequence.

The RTOP relies on its interrupt-handling scheme, which the vendor calls Macro Service Transfer, to transfer the data in the memory table to the RTOP buffer registers with only minimal CPU intervention

Interrupt-handling features reduce overhead

By their very nature, real-time-control systems are dependent on the efficient handling of interrupt requests. When an interrupt occurs, the μ controller must be able to service the request as soon as possible. The μ PD78312 μ controller (NEC Electronics, Natick, MA) utilizes conventional vectored-interrupt handling and, in addition, it incorporates two interrupt-handling features that reduce the amount of software overhead.

NEC calls the first feature Macro Service Transfer. In response to an interrupt request, the facility transfers data between memory and a special-function register without any software intervention. The μ controller has a number of separate Macro Service Channels located in the on-chip RAM, each of which consists of one 16-bit register and two 8-bit registers. One of the 8-bit registers, called the Macro Service Counter, de-

termines the number of transfers—as many as 256 are feasible. The counter decrements after each transfer.

The other 8-bit register, called the Special Function Register Pointer, specifies which special-function register is involved in the data transfer. The 16-bit Macro Service Pointer contains the source or destination memory address. In addition, an 8-bit Macro Service Control Register, associated with each interrupt, selects the designated Macro Service Channel.

The second feature, which the manufacturer calls Context Switching, makes use of the eight sets of general-purpose register banks located in the internal RAM. Each bank consists of sixteen 8-bit registers. You can pair two 8-bit registers to form a 16-bit register. For example, two of the 8-bit registers can function as the low-order and the high-order byte of a

16-bit accumulator.

When you enable the Context Switching feature, an interrupt request selects a register bank associated with the priority level of the interrupt. The new register bank loads a prestored vector address into the Program Counter (PC) while the current contents of the PC and Program Status Word (PSW) are saved in the RP2 and RP3 registers of the new register bank.

The program jumps to an interrupt routine pointed to by the new address in the PC and uses the new active register bank to perform the routine. When the routine is complete, the current active register bank transfers the saved words back into the PC and the PSW, respectively. Therefore, the firmware can select a new register bank for each interrupt request without needing additional software to save the current register contents.

Some μ controller features are optimized for real-time control tasks.

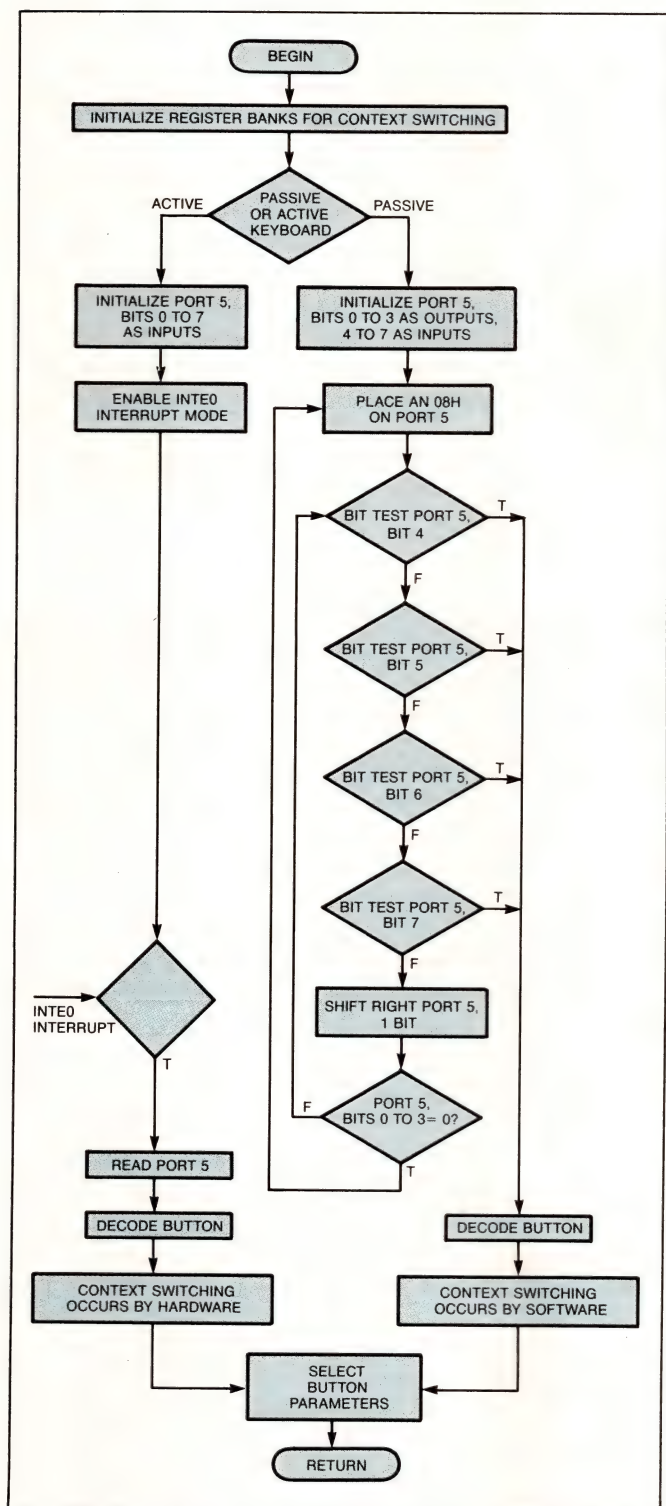


Fig 4—When the keyboard scan routine determines which key has been depressed, the Context Switching feature selects a register bank with preloaded data to service the interrupt.

(see box, "Interrupt-handling features reduce overhead"). The firmware first initializes the Macro Service Channel for four data transfers corresponding to the four motor phases. Upon recognizing an interrupt-request flag, the Macro Service Controller transfers data from memory to the buffer registers. Following the fourth transfer, a vectored interrupt reinitializes the Macro Service Channel. This type of interrupt-handling scheme allows the motor to be stepped four times with minimal CPU intervention. Fig 3's flow chart shows how to send data to the lower nibble of port 0 to control the stepper motor.

I/O, interrupt ports provide control links

One of the μ PD78312's I/O ports drives the solenoid that controls the pen height. To plot a point on the paper, the μ controller has to place this port in an active high state. The pen remains in the down position as long as the I/O port is in the active-high state. Driving the I/O port to its inactive-low state de-energizes the solenoid, allowing the pen to return to its up position.

If the program attempts to drive the pen beyond the maximum width of the plotter, a mechanical limit switch sends a command to the μ controller's nonmaskable interrupt (NMI) input. The edge-triggered interrupt initiates an NMI routine, which disables the X-axis stepper motor. To reset the X-axis motor, the routine initializes a counter to a count value equal to the width of the plotter.

To initialize the plotter and its limits at power-up, the Macro Service Transfer facility drives the X-axis motor to its limit. When the NMI signal occurs, the routine reverses the direction of the motor and places the pen position in the center of the plotter. During this centering motion, every fourth macro service step decrements the counter from the home position and provides a displacement to the other limit.

A scan routine interfaces to the keyboard

As mentioned earlier, the μ controller has to have a means of interfacing with each of the two control sources. A representative configuration of the keyboard control source, which serves as a good example, has 16 keys arranged in a 4×4 matrix. This keyboard interface occupies eight I/O ports on the μ controller. There are two types of keyboard, passive and active.

A passive keyboard, which is the most common, receives its power from the μ controller. To interface to a passive keyboard, the firmware must configure the eight I/O ports for four input and four output ports. The

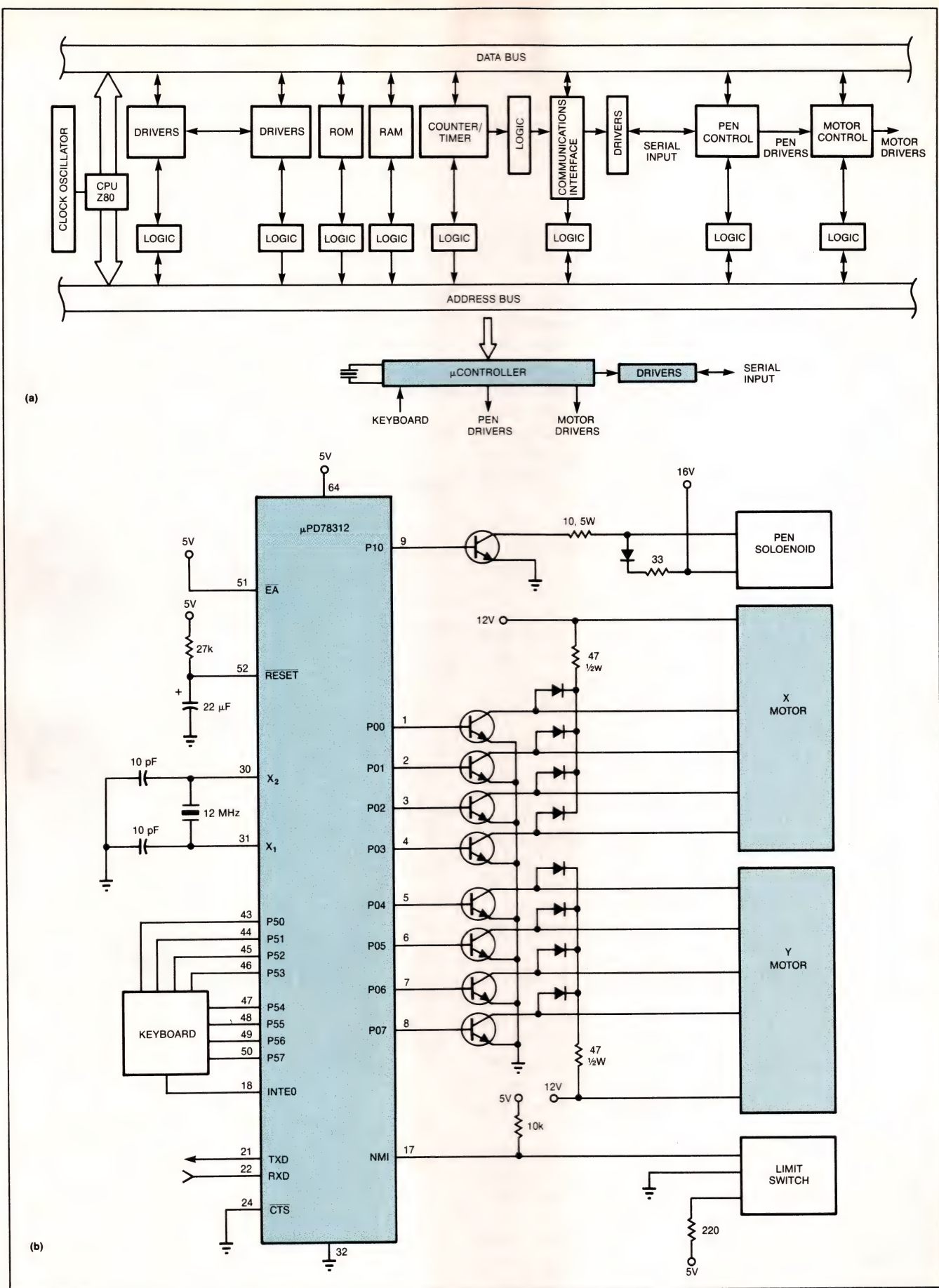


Fig 5—Compared with a traditional CPU board for an X-Y plotter, a μ controller requires minimal external hardware (a). The schematic in b shows the hardware you need to use the μ PD78312 in an X-Y plotter application.

The time interval fixes the time between phase changes and, subsequently, the motor speed.

μ controller then sequentially applies a voltage to each of the four row lines of the matrix and monitors the column lines to determine if a key is depressed.

An active keyboard receives its voltage directly from the power supply, and thus you can take advantage of the μ controller's standby mode. The firmware must configure all eight I/O ports as input ports that connect to the column and row lines of the matrix. When a key is depressed, a line from the keyboard to one of the maskable interrupt input lines wakes up the μ controller. When awoken, it searches the I/O ports to find the depressed key. Fig 4's flow chart shows the software required to service either type of keyboard.

The μ PD78312's Context Switching feature aids the programmer in the development of the firmware for servicing the keyboard (see box, "Interrupt-handling features reduce overhead"). Depending on which key you depress, the feature selects one of the eight sets of general-purpose register banks located in the internal RAM. You can preload these register banks with data to service a particular key. A good example is the scaling-parameter data that the keyboard needs to select a plot-scale change.

The serial-communication interface provides the means of transferring plot data to the controller. Customarily, and in the case of the μ PD78312, this interface transfers data asynchronously or synchronously and consists of a serial data input, a serial data output, a serial clock output, and a clear-to-send input. The plot program accesses serial input data from an on-chip 8-bit receiver buffer register. Using a 12-MHz crystal, a dedicated baud-rate generator is programmable for data-transfer rates of 110 to 38.4k baud.

On-chip memory is sufficient for the job

The functions resident on the μ controllers of today can easily accomplish all of the control tasks that an X-Y plotter application demands. To understand just how much real estate and components you can save by using a design such as the one presented here, refer to Fig 5a. Fig 5b shows the hardware necessary to implement a complete μ PD78312 X-Y plotter design.

Of course a μ controller has to have enough memory space to accommodate all of the requisite control functions. The NEC μ controller does; it can access 64k bytes of address space. The firmware for interpreting the input data and translating it to control the motors and solenoid is resident in the chip's 8k-byte internal ROM. The ROM address space ranges from 0000H to 1FFFH. A vector table, located from address 0000H to

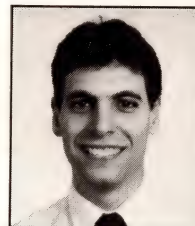
003FH, contains the interrupt branch addresses for the various interrupt requests.

The 256-byte RAM occupies the address space from FE00H to FFFFH. The first 128 bytes of RAM are available as a scratchpad area. This arrangement places the eight banks of general-purpose registers in the top 128-byte section. The special-function and control registers occupy the address space from FF00H to FFFFH.

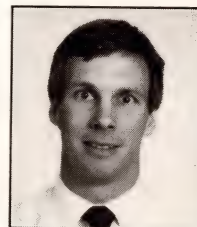
EDN

Authors' biographies

Marc Birnkrant is an application engineer at NEC Electronics Inc in Natick, MA, where he is involved in single-chip-microcomputer technical support. He previously worked for the Link Flight Simulation Div of Singer, and he holds a BSEE from the University of Rochester in New York. Marc fixes up old homes and likes to ski in his off hours.



Stephen Beckwith is a senior application engineer at NEC and is also responsible for single-chip-microcomputer technical support. Before he began working for NEC, he was in the Navy for five years. Stephen attended the University of Lowell in Massachusetts.



Article Interest Quotient (Circle One)
High 488 Medium 489 Low 490

On April 5th, Intel made a major announcement about advanced 32-bit embedded control technology.

On April 12th, we'll explain it.

Intel unveiled three advanced embedded control technologies, two 32-bit embedded processors, and a radically new memory product line on April 5th.

On April 12th, seminars begin worldwide to show how to design significantly more powerful 32-bit systems that provide unparalleled price performance. The fully supported 80376 and 80960 families of embedded processors, and the breakthrough flash memory technology will be discussed in detail.

These free seminars will include lectures, comprehensive demonstrations, printed materials and a good lunch.

You're invited.

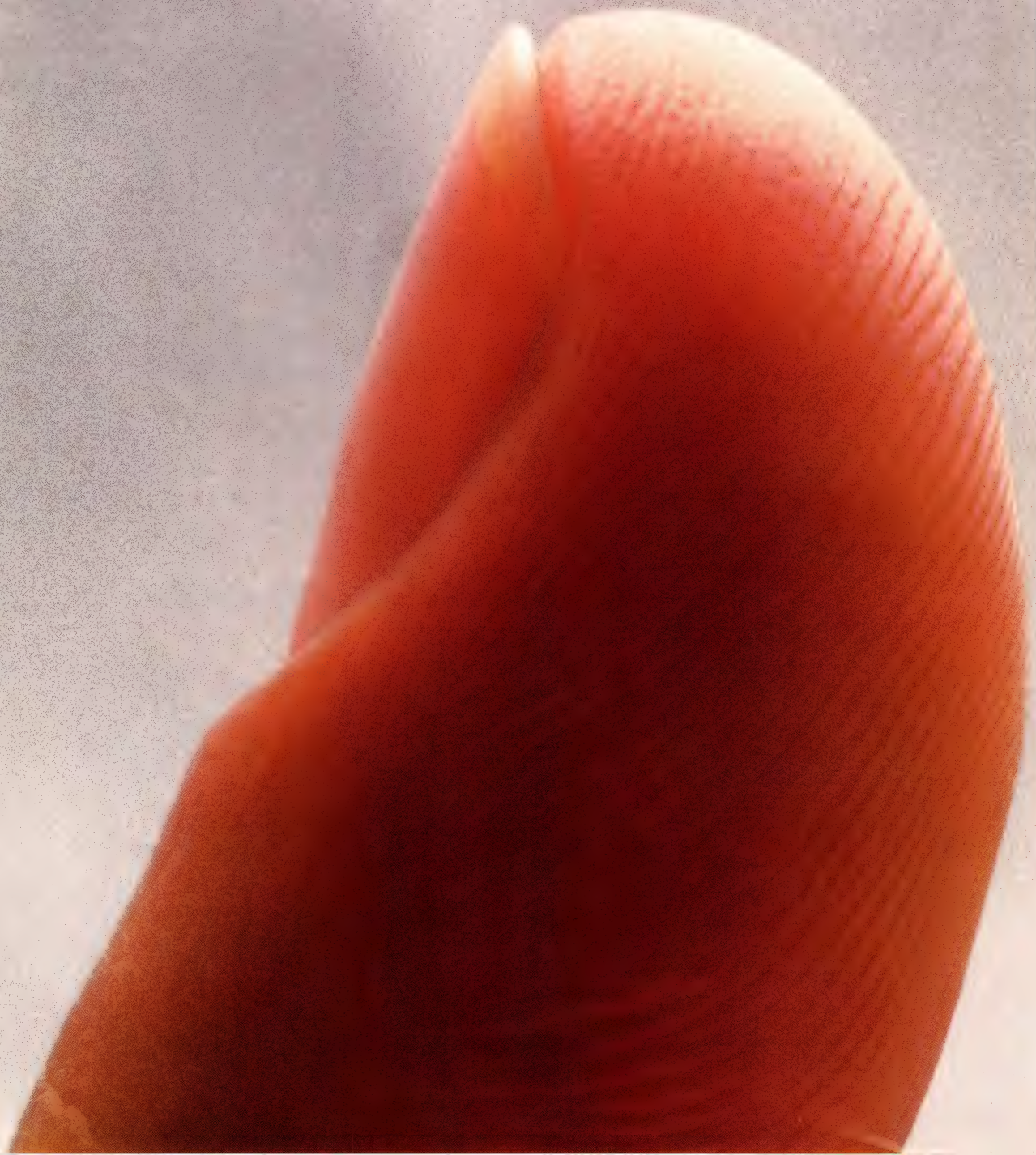
Call (800) 548-4725 for details, or to secure a spot.

And call now, as seating is limited, and we have a lot of explaining to do.



Alabama	Huntsville	4/29/88	Maryland	Baltimore	4/26/88	Pennsylvania	Philadelphia	4/12/88
Arizona	Tempe	4/18/88	Massachusetts	Boston	4/15/88		Pittsburgh	5/18/88
California	Anaheim	4/22/88	Michigan	Detroit	4/25/88	Texas	Austin	4/21/88
	Los Angeles	4/20/88	Minnesota	Minneapolis	4/14/88		Dallas	4/19/88
	San Diego	4/21/88	Missouri	St. Louis	5/19/88		Fort Worth	4/18/88
	Santa Clara	5/4/88	New Jersey	Kenilworth	5/13/88		Houston	4/20/88
	Van Nuys	4/19/88	New York	Binghamton	5/11/88	Virginia	Charlottesville	4/28/88
Colorado	Denver	5/3/88		Long Island	4/13/88		Tysons Corner	4/27/88
Connecticut	Stratford	4/14/88		Rochester	5/10/88	Washington	Bellevue	5/5/88
Florida	Ft. Lauderdale	4/28/88		Tarrytown	5/12/88	Wisconsin	Milwaukee	4/13/88
	Orlando	4/26/88	North Carolina	Charlotte	5/4/88	Canada	Montreal	5/24/88
Georgia	Atlanta	4/25/88		Raleigh	5/3/88		Ottawa, Ontario	5/25/88
Illinois	Chicago	4/12/88	Ohio	Cleveland	5/19/88		Toronto	5/20/88
Indiana	Indianapolis	5/17/88		Dayton	5/17/88		Vancouver, BC	5/6/88
Kansas	Kansas City	5/18/88	Oregon	Portland	5/6/88			

How to please significant portion



e a small but of your customers.

Pushbutton-operated devices are much more marketable when the buttons respond in satisfying ways to the user's touch.

So we made our new SLP control panels a touch more responsive.

We increased button travel to a more comfortable .050".

And we incorporated an enhanced conductive rubber pad, tested to ten million operations, that rewards the finger with a satisfying snap back when a button is actuated.



The result is a control panel that adds to a user's comfort and confidence, for about the same price as those that generate feelings of vagueness and uncertainty.

But that's not the only bright feature of these new controls.

You can also get them in full-face, LED lighted versions that show up unmistakably, even in broad daylight.

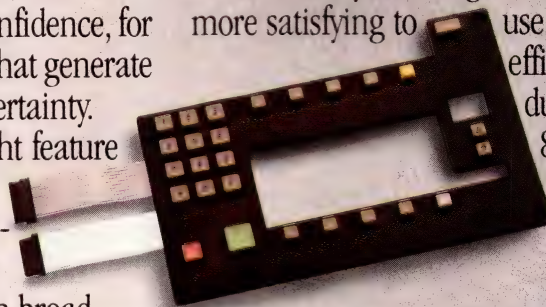
And each button can be made to light independently of its on/off status,

enabling the panel to guide a user through a sequence of operating steps.

These new panels are available off-the-shelf in several standard arrays, or in custom packages with microprocessors, visual displays, special enclosures, or attachment cable included.

Making controls more responsive is just one of the many ways we can help you build competitive advantages into your products.

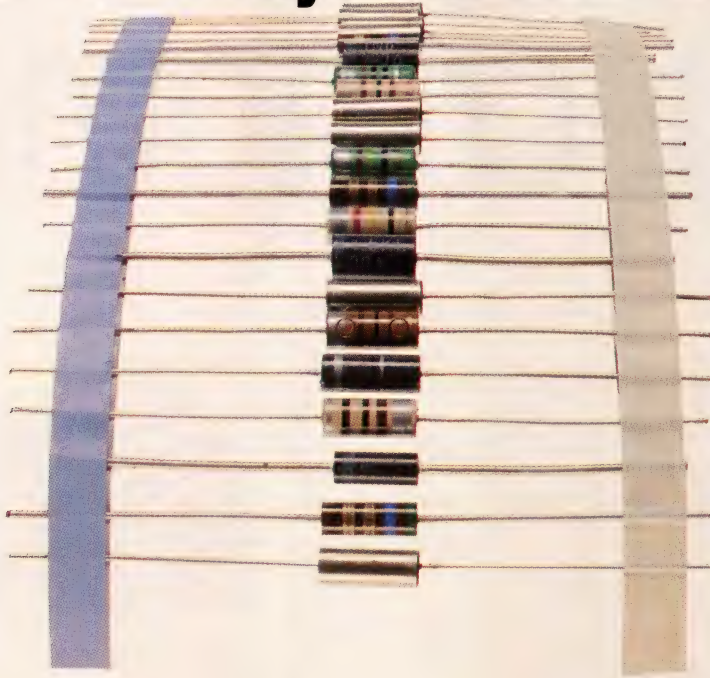
To make your designs easier to sell, more satisfying to use, or more cost-efficient to produce, call us at 815-235-6600.



Together, we can find the answers.

MICRO SWITCH
a Honeywell Division

Now your CMOS backup battery can be what you've always wanted it to be.



Just another component.

Forget those labor intensive methods normally required for printed circuit board mounting of batteries. Our new axial lead μ PowerCells™ (Lithium Iodine 2.8V Solid CMOS Backup Cells) look like a resistor or capacitor. They're about the same size and they don't need special handling. You can put them on a sequenced tape reel for automatic printed circuit board insertion. And like most other components, μ PowerCells™ can be wave soldered, cleaned and dried us-

ing normal procedures.

Once they're in place, μ PowerCells™ are dependable. Their Lithium Iodine chemistry is the number one choice for powering cardiac pacemakers. And a performance study of over 1 million batteries in use shows that a useful life of more than 20 years can be predicted.

At 35 milliamp-hours, the axial lead μ PowerCell™ will handle most CMOS backup problems. However, higher capacity versions to 1 amp hour are

available in a new space-saving rectilinear package. The Catalyst Research line includes modules for sensing power loss and transferring to battery backup as well as clock modules with battery built in.

Best of all, Catalyst Research μ PowerCells™ are priced like other components.



For more information, call us at 301-296-7000 ext. 304.

CATALYST RESEARCH
A DIVISION OF MINE SAFETY APPLIANCES COMPANY

1421 Clarkview Road Baltimore, MD 21209-9987, USA Telephone (301) 296-7000 ext 304 Telex 898095 CATALYST

Lithium cells keep CMOS RAM alive during line outages

Until recently rechargeable nickel cadmium batteries were the only choice for memory backup. The advent of CMOS RAM has lowered typical memory-backup power requirements to 2 to 3 μ A at 2.0V, even for memories of 1M bits or larger, and now lithium batteries are feasible for such applications.

Nicolas Müller and Henry Uebelhart, *Renata*, and Jack F Swartz, *International Power Sources*

In the past, an engineer was forced to design with nickel cadmium (NiCd) batteries and had to account for all their limitations: NiCd batteries have a high self-discharge rate, require a sophisticated charging system for optimal performance, occupy a great amount of board space, cannot be wave soldered, and have disposal restrictions due to their poisonous cadmium content. CMOS RAM, however, doesn't need a backup power source with high drain capability. Moreover, NiCd batteries require three cells in series to satisfy such an application, but lithium batteries require only a single cell.

For a typical 250-mAhr lithium cell, the calculated battery life at CMOS drain levels, operating continuous-

ly, is about nine years. Lithium cells need no recharging during their service life. Further, because lithium cells exhibit extremely low rates of self-discharge ($<1\%/yr$), they have a long shelf life if not subjected to high temperatures or short circuits.

You should always calculate battery-backup capacity based on a 100% duty cycle, even if your system will receive its power mostly from the mains power supply. The battery's surplus capacity will compensate for leakage currents as well as the self-discharge of the battery caused by possible rises in ambient temperature.

Which lithium chemistry is right?

The lithium in a lithium cell forms only the anode material of the cell; manufacturers use a wide variety of materials for the cathode and electrolyte. The two main lithium-cell types are the liquid-cathode chemistries such as thionyl chloride ($Li/SOCl_2$) and sulphur dioxide (Li/SO_2) and the solid-cathode types such as manganese dioxide (Li/MnO_2) and carbon monofluoride (Li/CF). You must give careful consideration when selecting a lithium chemistry because each has advantages and disadvantages.

Liquid-cathode batteries have higher cell voltages and drain currents, but possess significant drawbacks such as a varying capacity dependent on cell orientation, caustic and polluting chemicals, and susceptibility to explosion. Consequently, liquid-cathode cells aren't suitable for user-replaceable applications. Although liq-

Because data retention now requires such little power, you can use primary cells.

liquid-cathode cells have a high theoretical energy density, their actual energy density is lower because of the rugged construction techniques required to safely hold their reactive constituents.

For memory-backup applications, the most significant disadvantage of liquid-cathode cells compared to solid-cathode cells is, paradoxically, their higher cell voltage. Their 20% higher cell voltage over solid-cathode cells (3.6 vs 3.0V) results in a 20% higher drain current for the same load. Therefore, a liquid-cathode cell requires a capacity 20% higher than a solid-cathode cell to achieve the same useful life. Note, however, that some older clock-chip designs, unlike memory ICs, have

a strict 3V minimum requirement; in these cases, a single lithium cell won't suffice. The IBM PC employs a module containing two lithium cells in series to ensure adequate backup voltage.

Solid-cathode cells are available encapsulated in plastic. Encapsulated cells avoid the problems associated with exposed cells that have been mounted in holders or with solder tabs. Exposed cells, in time, can suffer the additional self-discharge arising from accumulated residue on the cell's surface. This residue can come from dust, soldering and washing operations, and handling. Encapsulation not only protects cells from the environment, but provides extra sealing against moisture diffu-

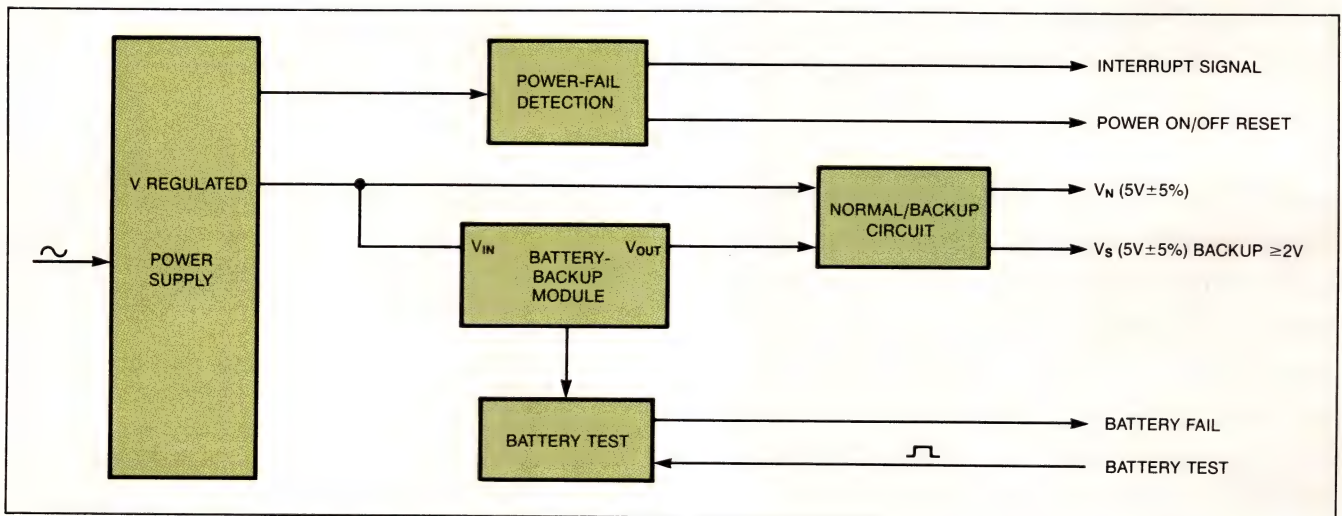


Fig 1—This circuit provides safe data retention during a power interruption.

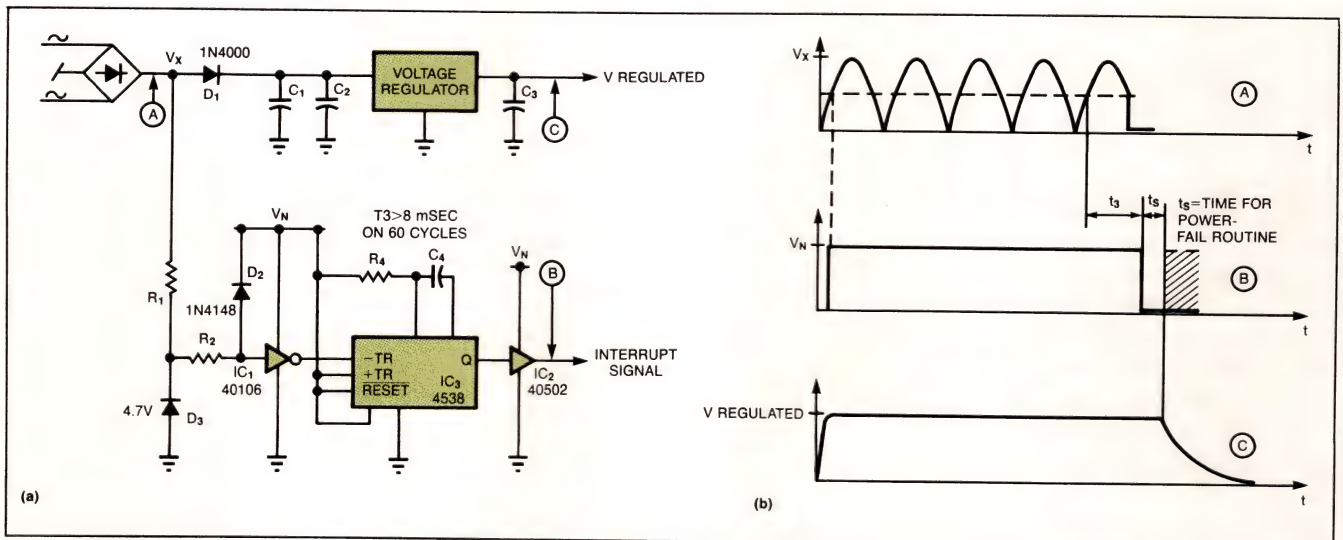


Fig 2—A simple one-shot, IC_3 , detects a mains failure within a half cycle.

sion and electrolyte evaporation. It also reduces the possibility of shorting cells.

You can also obtain encapsulated cells with optional decoupling diodes. Memory-backup applications normally require two decoupling diodes: one to avoid discharge through the mains power supply when it's shut down and another to prevent the charging of the battery during normal power conditions.

Saving data during power outages requires more than simply plugging a battery into your circuit. Fig 1 shows the block diagram of a circuit that provides safe data retention during a power interruption. The CPU must be capable of early recognition of an interrupt if its power-fail routine is to store critical data in the buffered RAM before the voltage drops below the allowed tolerance of the processor. The circuit in Fig 2a detects a mains failure within a half cycle ($f=60$ Hz, $t_s < 8$ msec.) (Fig 2b is the timing diagram.)

If your system doesn't provide a 120-Hz signal, you must monitor the input level to your power supply's voltage regulator with a comparator. The circuit in Fig 3a uses an Intersil ICL 8211, a special-purpose, low-voltage detector. Because the input voltage to the regulator includes ac interference, the ICL 8211's hysteresis pin is connected to avoid forming unwanted pulses at the output of the device. You must carefully select C_1 (Figs 2a and 3a) to maintain a minimum voltage ($5V \pm 5\%$ typ) through the duration of the CPU's power-fail routine.

In most cases, the CPU can provide the power-on

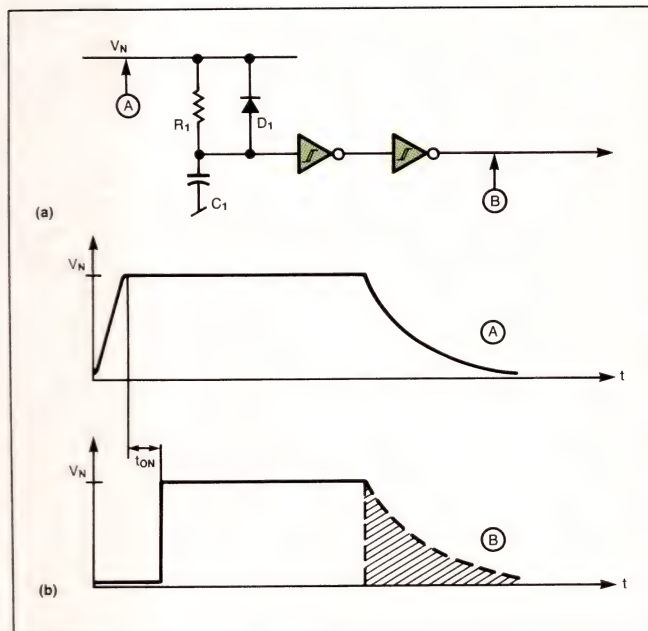


Fig 4—If your CPU doesn't provide a power-on signal, you will need an additional RC circuit such as this one. The circuit introduces an additional delay, t_{ON} , after the power supply returns to its normal level, V_N , to protect the CPU from transients on the interrupt line caused by unstable returning mains power.

signal. If it can't, you'll need an additional RC circuit. Fig 4a shows a typical circuit, and Fig 4b shows its timing diagram. The RC circuit introduces an added delay, t_{ON} , after the power supply returns to its normal level, V_N , to protect the CPU from transients on the

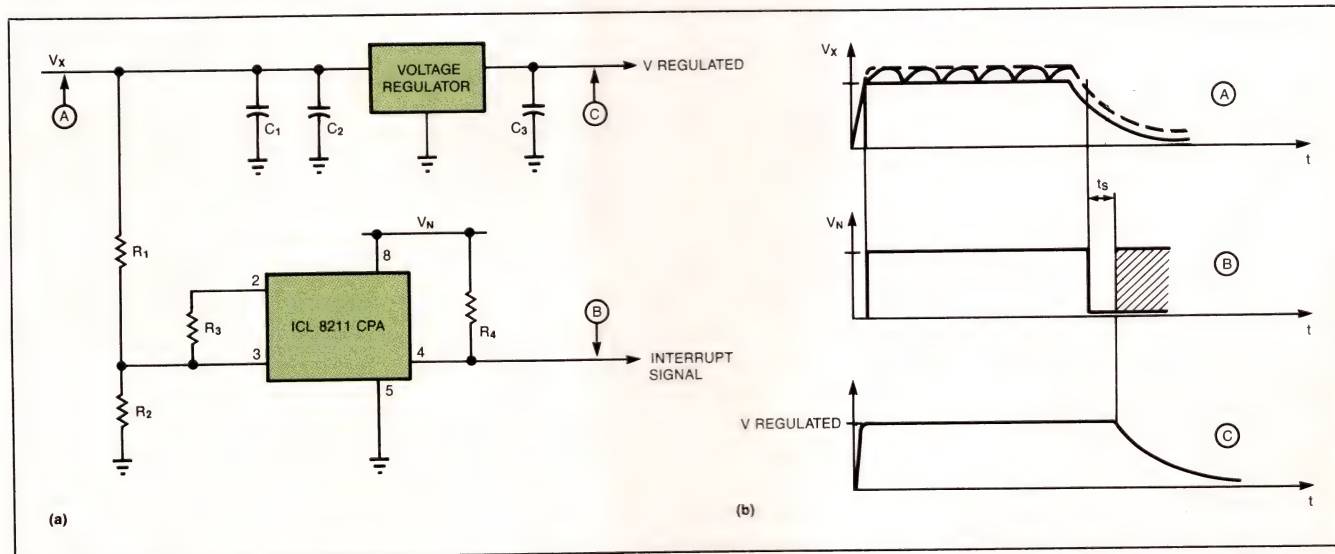


Fig 3—A special-purpose, low-voltage detector provides superior performance to Fig 2's one-shot. Because the input voltage to the regulator includes ac interference, the ICL 8211's hysteresis pin (pin 2) is connected to avoid forming unwanted pulses at the output of the device.

You should always calculate battery-backup capacity based on a 100% duty cycle even if your system will be powered mostly by the mains power supply.

interrupt line caused by unstable returning mains power. You could possibly use the $+V_S$ level (see Fig 1) for this circuit's power supply, but such a scheme would result in additional drain on the battery and thus require a larger battery.

For this power on/off-reset application, the circuit in Fig 5a provides better performance than the preceding simple RC circuit. C_4 in Fig 5a determines the time delay, t_{ON} . Usually, you should select C_4 so that the on delay is shorter than the off delay.

Aside from using a pair of decoupling diodes, you

have the choice of several other power-supply decoupling techniques. The circuits that follow assume a typical power supply with an output voltage of 5V dc $\pm 5\%$. As Fig 6a shows, diode D_1 decouples the lithium battery from the power supply, preventing battery discharge through the power supply when it is off. When the power supply is operating normally from mains power, voltage to the buffered circuits drops by V_1 , the voltage drop across D_1 . If your application requires that your unbuffered and buffered circuits operate at the same voltage level, you must add a diode,

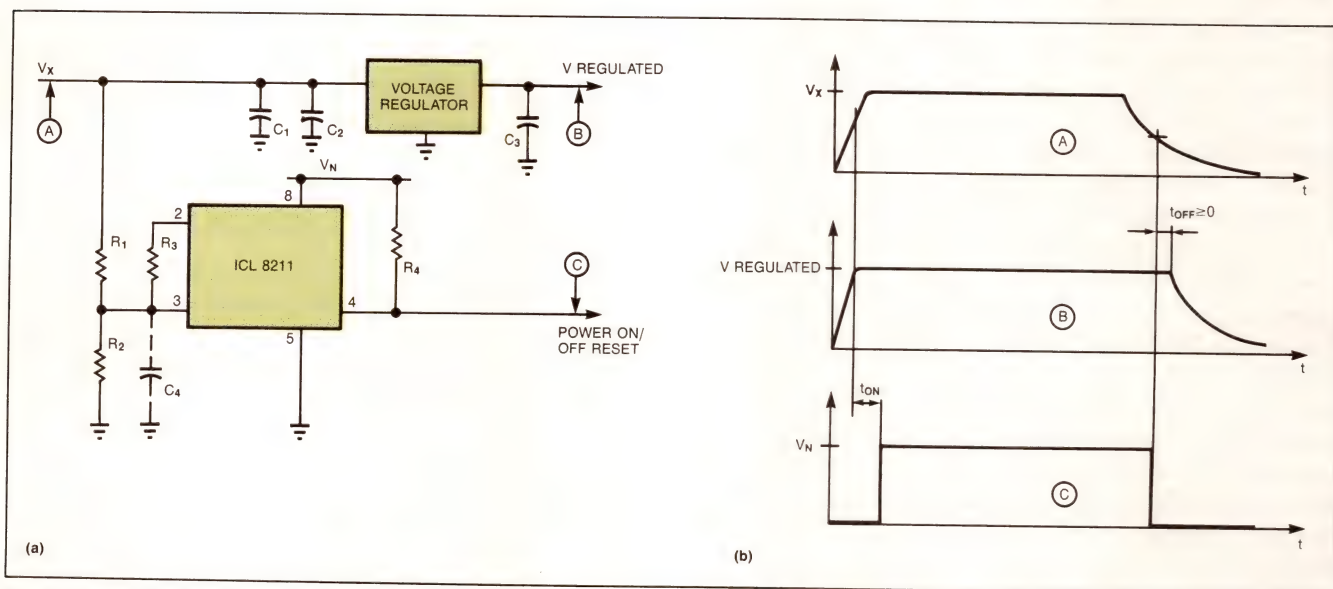


Fig 5—Again, the ICL 8211 provides better performance than a simple device. In this circuit, the ICL 8211 replaces Fig 4's Schmitt triggers.

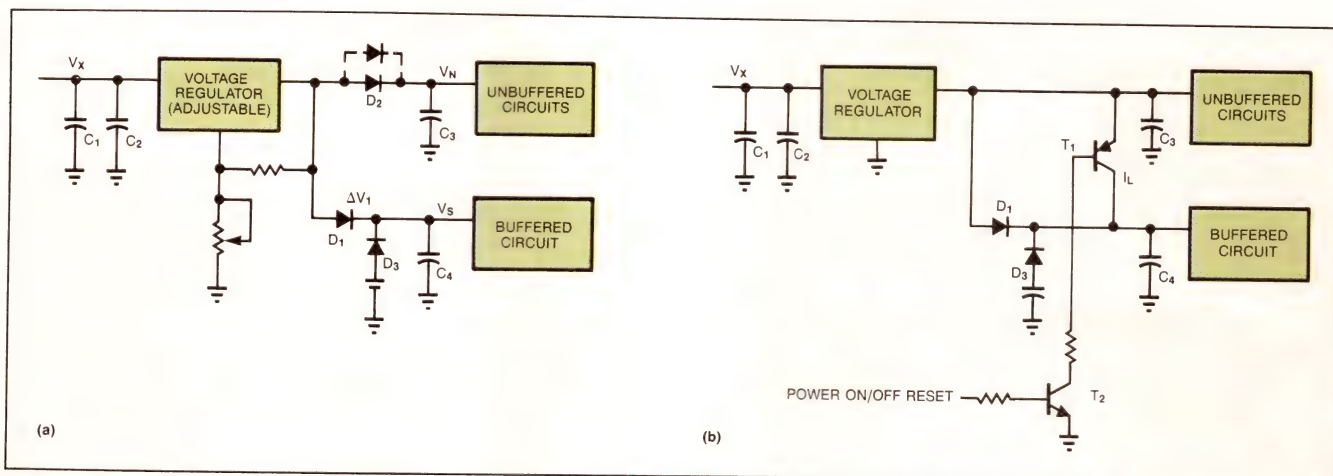


Fig 6—Diode D_1 decouples the lithium battery from the power supply. Diode D_2 ensures that the buffered and unbuffered loads see the same voltage level. This scheme requires an adjustable regulator; if you select a fixed regulator, you will have to use a decoupling transistor (or relay) as in b.

...TO THE ENDS OF THE EARTH

**ELECTROCHEM
QUALITY LITHIUM
POWER SOURCES**



Sometimes you need power in the most remote, hostile environments... like data gathering stations in sub-zero climates. That's a service call nobody wants to make.

In extreme cases like this, specifiers rely on incredibly powerful, dependable and long lasting Electrochem lithium batteries.

But you don't have to operate on a frozen tundra to experience the advantages of lithium power sources... they work in critical everyday applications like metering devices, memory backup, telemetry and many more.

Why lithium? Today lithium power sources represent a highly developed technology offering distinct advantages over other battery types... like high voltage, light in weight, adaptable to virtually any climatic condition, extremely reliable performance for years with no recharging required. In short, better overall operating efficiency.

Why Electrochem? We're a leader in lithium power sources, and we'll go to the ends of the Earth to meet your power source needs. But chances are we won't have to because we have a wide range of lithium batteries, and packs, for almost every conceivable application... in stock.

Our team of power source experts is ready to take on your next challenge. They'll introduce you to our exclusive CELlection program... to determine your needs and provide the most effective and efficient solution.

When you need a reliable power source that will go to the ends of Earth, look no farther than Electrochem.

For more information on lithium power sources, and our CELlection program, call (716) 759-2828 and say "Hello, Electrochem!"



DIVISION OF WILSON GREATBATCH LTD.
10,000 WEHRLE DRIVE
CLARENCE, NEW YORK 14031
(716) 759-2828 TELEX: 91-386

If its power-fail routine is to store critical data in the buffered RAM before the voltage drops, the CPU must recognize the interruption early.

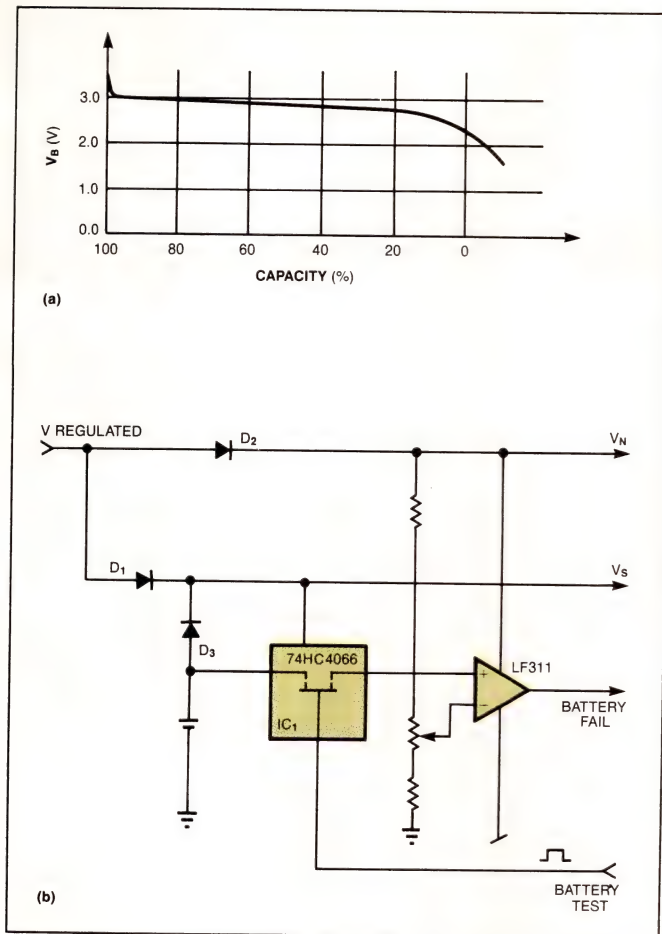


Fig 7—The circuit in b takes advantage of a lithium cell's drop in open-circuit voltage to respond to a query from the CPU with the cell's charge state.

D_2 . If currents to the two loads are significantly different, you can add a parallel diode to diode D_2 to compensate for the resulting difference in diode-voltage drops. In this configuration, you'd also need a variable regulator, adjustable over the required tolerance range.

If you have a fixed voltage regulator instead of an adjustable one, you can employ a decoupling transistor such as T_1 in Fig 6b to equalize the buffered and unbuffered supply voltages. This solution, however, is more complicated and expensive and requires additional board space. You should select T_1 to have the lowest reverse-leakage current (I_L) possible to minimize battery drain. To eliminate T_1 's reverse leakage, you could replace it with a relay, but not all relays can conduct microamperes of current successfully. A mercury-wetted relay works best in this application.

To ensure uninterrupted memory backup, you must

check the battery's state during regular system maintenance or, in a critical application, you must employ a continuously operating battery-state monitor. Luckily, a direct correlation exists between the open-circuit voltage of an LiMnO_2 cell and the cell's remaining capacity. Fig 7a is a graph of cell voltage vs remaining capacity. After a cell discharges by approximately 80%, you can detect a gradual drop in its output voltage. Liquid-cathode batteries, in contrast, do not exhibit this warning behavior; they have an abrupt voltage drop that occurs when they are fully discharged.

Fig 7b shows a typical circuit for monitoring the capacity of a lithium battery. After the system switches to power-supply operation, the CPU pulses the analog switch (74HC4066) and checks the state of the battery-fail output. You should use a reference level of 2.5V to compensate for the 0.3V drop across D_3 that will occur during a power interruption. Also, don't forget to include the additional drain (2 μA typ) of the 4066 when calculating the capacity of the battery.

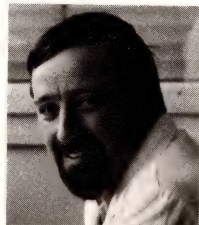
EDN

Authors' biographies

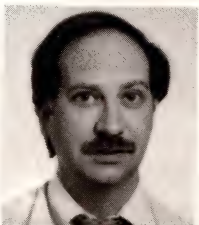
Nicolas Müller is responsible for worldwide marketing sales and marketing for OEM lithium batteries for Renata AG in Switzerland. He previously worked for several electronic component manufacturers in South America and Switzerland. Nicolas enjoys skiing and is an avid collector of model trains and trolleys.



Henry Uelbelhart is involved in the design and development of control and test systems for a fully automated production facility for Renata AG in Switzerland. Henry enjoys hiking and swimming and has traveled extensively throughout Europe.



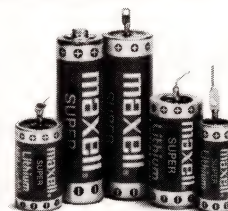
Jack F Swartz is one of the founders of International Power Sources Inc in Natick, MA. He previously worked for the power supply division of General Instrument. Jack's leisure activities include photography and computer programming.



Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499

POWER PLUS SAFETY.

The Maxell Super Lithium Battery.*
Good for a decade, these lithium thionyl
chloride batteries are hermetically
sealed for super
safety plus long
shelf and service
life. And at 3.6
volts, they
supply the
high energy



density you're looking for.
Specify Maxell Super Lithium
Batteries for critical
applications where a safe
battery is imperative.

Specify Maxell Super
Lithium Batteries for quality
and a name you can trust.
When you need power
and you need it safe,
look for Maxell.

maxell®

Maxell Corp. of America
22-08 Route 208
Fair Lawn, NJ 07410

*Recognized under the
Component Program
of Underwriters
Laboratories.



**NOBODY TOOK US
SERIOUSLY,
WHEN WE ANNOUNCED
THE MT RELAY.**

But then, we were shooting for the stars.

We felt, though, that that was the only way to show the world that something extraordinary could come out of Europe:

So in the beginning we prepared a list of proposed functions that would silence absolutely any critic.

Firstly we rather boldly decided to make the MT relay monostable. The non-polarized building principle in which no parts are premagnetized requires a significantly higher material cost. The advantage of a significantly increased packing density seemed to us to be worth it.

Then, the relay had to be compatible with the world standard. We wanted to offer our customers the maximum flexibility.

Re-adjustment was an additional point. We thought this should be completely done away with in the MT relay. An operating temperature range of from -55 to +70 degrees centigrade as well as a failure rate guaranteed never to exceed 0,5% (of



Dr. Juchli 779 STR

course over the lifetime of the relay) also seemed to us to be a foregone conclusion.

But what really brought down the house for our critics in the beginning was our audacious assertion that one day this relay would be available with a power consumption of 400, 200 and 150 mW. And at 5, 12, 24 or 48 volts.

Truly an ambitious claim.

Firstly, we had to invest heavily in material research in order to also guarantee in the world of micro technology that optimal conductivity and contact security could be obtained.

On the designer's drawing board, we had to lay the foundation for a completely new production technology. After all, no one had yet been capable of spooling a 25 micron thick copper wire without the danger of breaking it.

Yes, we had to do quite a few new things. Carefully examine new things. Find new methods.

But it was worth it.

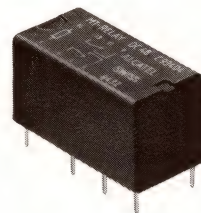
The new MT Relay with its record-breaking minimal power consumption: 150 mW at 48 volts e.g. And all that at a delivery price right in the middle of the price spectrum. We would be happy to send you additional information about this extraordinary product

Company

Address

Responsible Party

Standard Telephon und Radio AG, CH-8055 Zurich
Friesenbergstrasse 75, Switzerland



ALCATEL

STR

FOR EMI SHIELDING COMPLIANCE:

HARD WORK...

OR EASY CALL



Faced with designing or testing a product which must comply with one of the many commercial or military EMI specifications? You have two choices:

You can dig through the mountain of published material...and still not be much further ahead.

Or, you can make one easy phone call to Chomerics. Because whatever standards you're dealing with, our people know them inside and out. No other supplier delivers the combination of knowledge, products, and services to make your EMI problems disappear.

Design Help

Call us early on in the design phase of your product and take advantage of our no-charge EMI design review. We'll help you get it right the first time.

Applications Assistance

With your design criteria in mind, we'll look across the full range of EMI shielding possibilities, and provide detailed drawings and prototypes on short notice.

EMI Testing

Our depth of experience becomes very important when it's time to test your system. The fact that we operate comprehensive military and commercial testing facilities, with on-site design, applications support, and materials manufacturing, is a real advantage to our customers.

BEFORE CONSULTING THE SPECS, CONSULT THE SPECIALISTS.

CHOMERICS
a GRACE company

77 Dragon Court • Woburn, MA 01888
TEL: 800-225-1936 (In MA: 617-935-4850) • TWX: 710-393-0173

Chomerics (UK) Ltd.
Unit 8, First Avenue • Globe Park Industrial Estate
Marlow, Bucks., SL7 1YA • ENGLAND
TEL: (06284) 6030 • TELEX: 849817 CHOMER G

DESIGN IDEAS

EDITED BY TARLTON FLEMING

Compute square root of bipolar magnitudes

Rand H Hulsing II
Sundstrand Data Control, Redmond, WA

In Fig 1, a single analog-multiplier IC calculates the square-root magnitude for bipolar input signals. You normally define the square root only for positive arguments, but this circuit generates $\sqrt{V_{IN}}$ for positive inputs and

$$-\sqrt{|V_{IN}|}$$

for negative inputs.

Although IC₁ handles both input polarities, an output summing amplifier (IC₂) must combine the signals corresponding to each polarity, which appear on the separate load/summing resistors, R₂ and R₃. The circuit produces $\pm 10V$ output swings, limited to about 10 kHz by the multiplier's output amplifier (A). (This amplifier ensures equality in the V_{OUT} equation (Fig 1) by forcing the two terms within the brackets to have equal magnitudes.)

Fig 2 shows the circuit's output (V_O) superimposed on a $\pm 20V$ p-p, triangle-wave V_{IN}. Note that V_O=V_{IN} at 0V and at the 10V peaks. You can create an inverting version of the circuit by swapping the Z1 and Z2 inputs

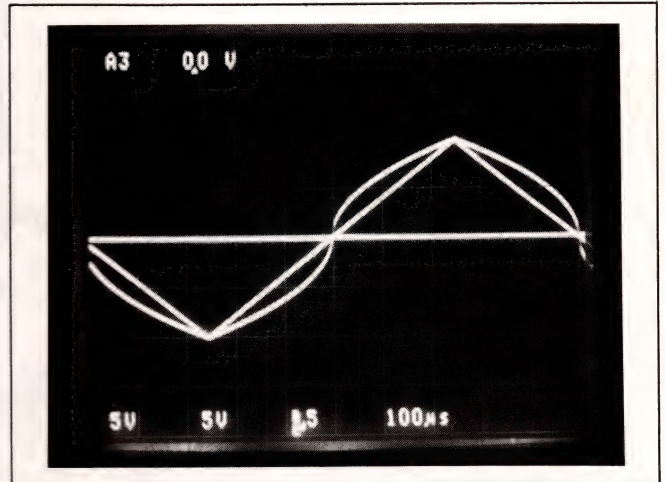


Fig 2—This photo shows Fig 1's V_O waveform superimposed on V_{IN}—a 20V p-p triangle wave.

(pins 3 and 8). As shown, the circuit delivers accuracy as high as $\pm 0.5\%$, depending on the electrical grade of IC₁. If you can tolerate $\pm 5\%$ accuracy, you can remove D₁, D₂, and R₁, and connect pin 4 directly to pin 7. **EDN**

To Vote For This Design, Circle No 750

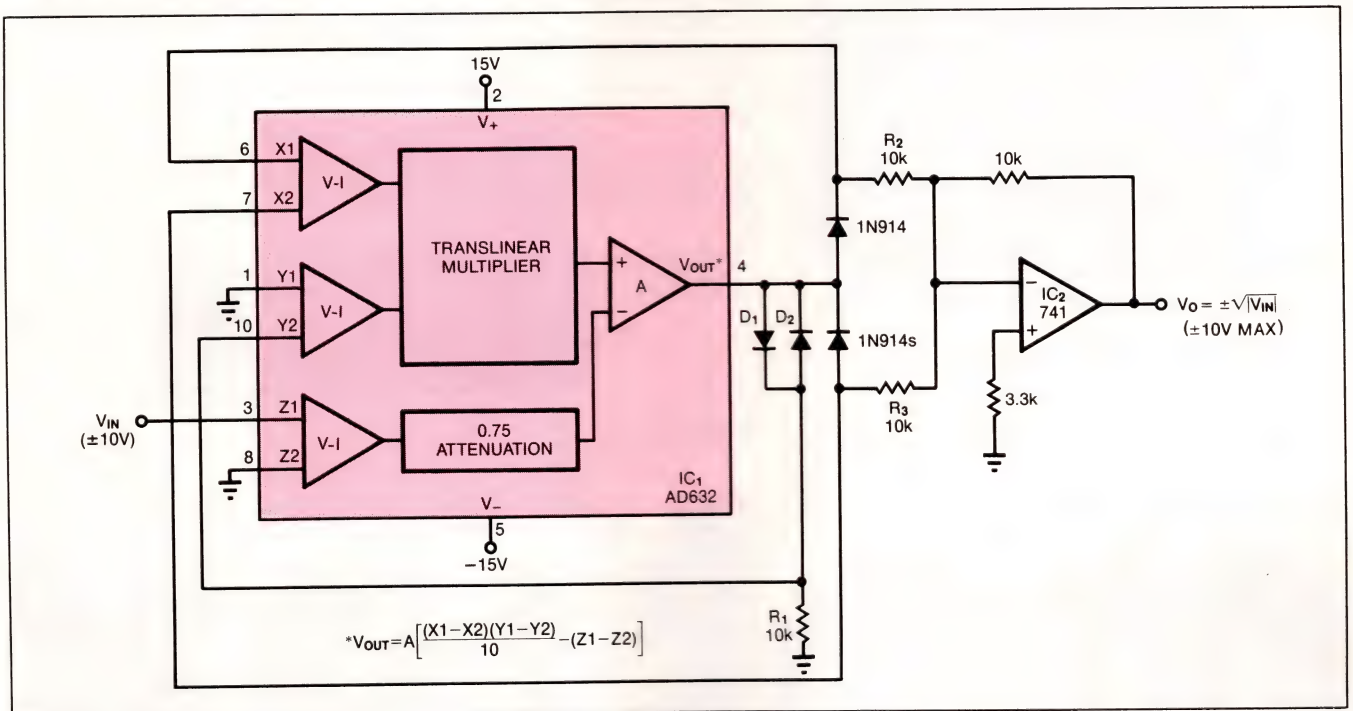
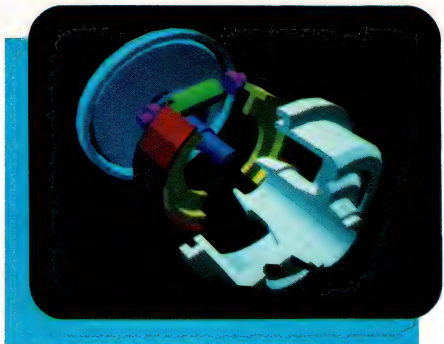
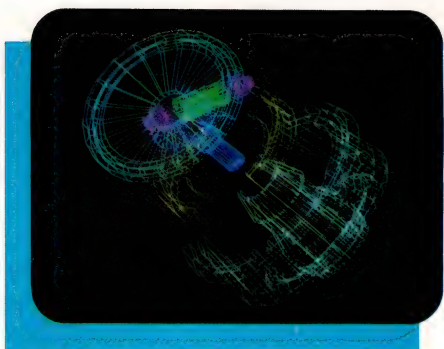


Fig 1—These circuit connections enable a single analog multiplier (IC₁) to calculate square-root magnitude for a bipolar input signal. Summing amplifier IC₂ combines the signals corresponding to each polarity.

One. Two. 3D.



Draw 20,000 Gouraud-shaded polygons a second...
90,000 3D vectors a second.

Choose 256 colors from 16.7 million.

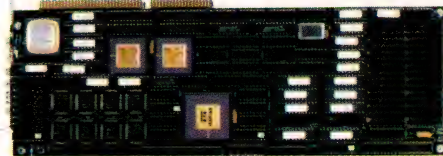
Turn a desktop PC AT into a professional 3D CAD workstation with the Matrox **SM-1281** graphics controller.

Based on the Matrox PG-1281 graphics processor for 2D workstations, the **SM-1281's** pipelined architecture has been optimized for sophisticated 3D processing. For the price of a single board, the **SM-1281** gives your PC AT the performance of high-end 3D graphics systems.

■ True workstation resolution [1280 × 1024] ■ High-level 3D primitives ■ Extensive display list capabilities ■ Hardware hidden surface removal ■ Depth cueing ■ Programmable light sources ■ Z-buffering

One, two, three. Don't wait to see.

1-800-361-4903



CIRCLE NO 86

A LEADER IN VIDEO MICRITECHNOLOGY

matrox

In Canada, call (514) 685-2630. PC AT and Matrox are registered trademarks of International Business Machines Corporation and Matrox Electronic Systems Ltd. respectively.

EDN - 3D/588

Counter controls its own clock frequency

Shantha Fernando

Arthur C Clarke Centre, Moratuwa, Sri Lanka

You can implement a finite-state machine by properly decoding the outputs of a binary counter. Driving the counter with a constant-frequency clock signal produces output states of equal duration. **Fig 1's** circuit, however, produces output states with different time intervals, as most applications require.

The analog multiplexer, IC₃, selects a timing resistor for the timer, IC₁. The timer's output clocks the counter

(IC₂) and the counter outputs drive the multiplexer's address inputs. The resistor values shown (R_{T0} through R_{T7}) produce a chirped clock and an ascending sequence of output-state durations, but you can generate arbitrary durations by choosing other resistor values. You can obtain longer durations by increasing the resistor values or by inserting a digital divider between the timer and the counter.

EDN

To Vote For This Design, Circle No 748

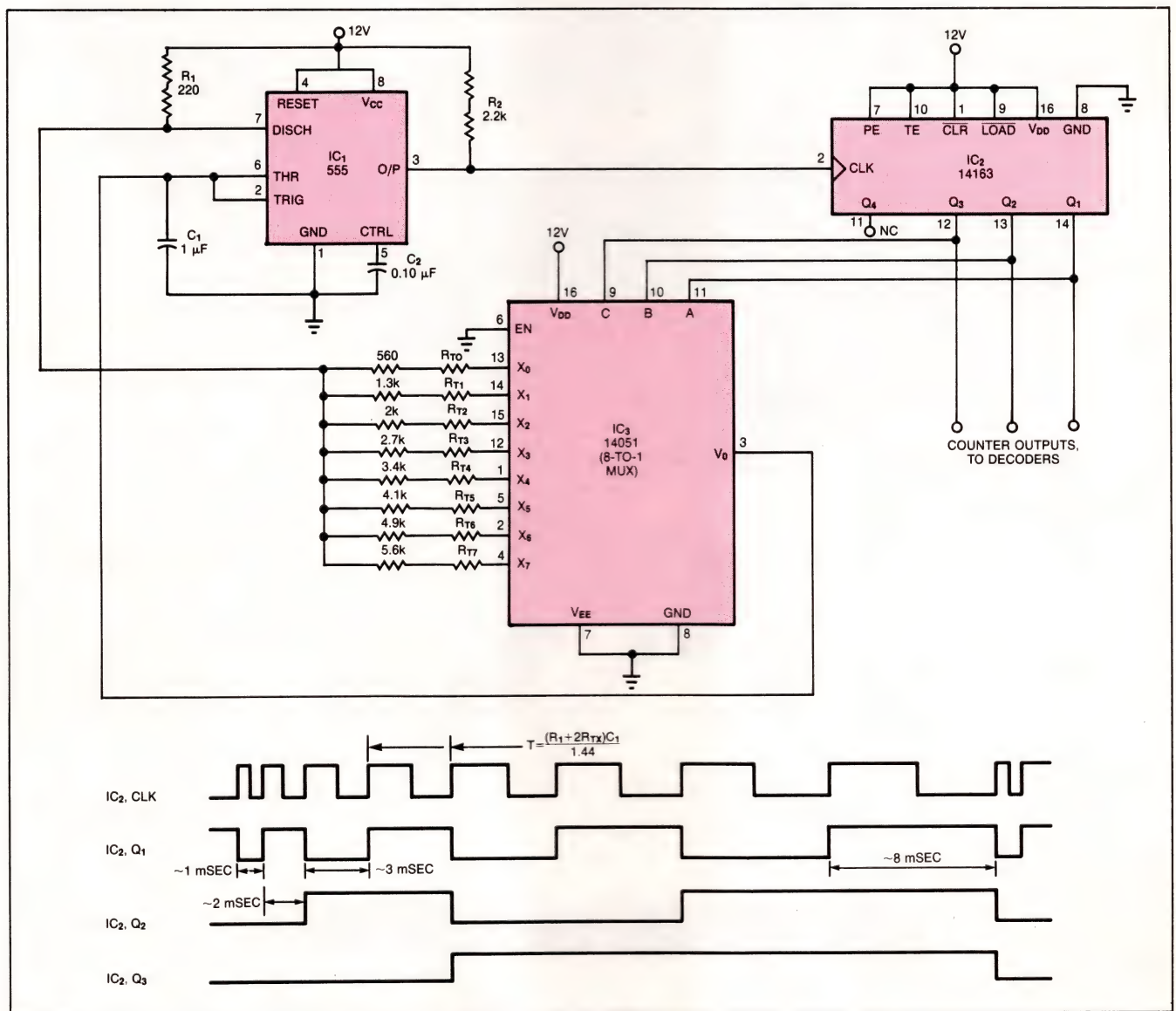
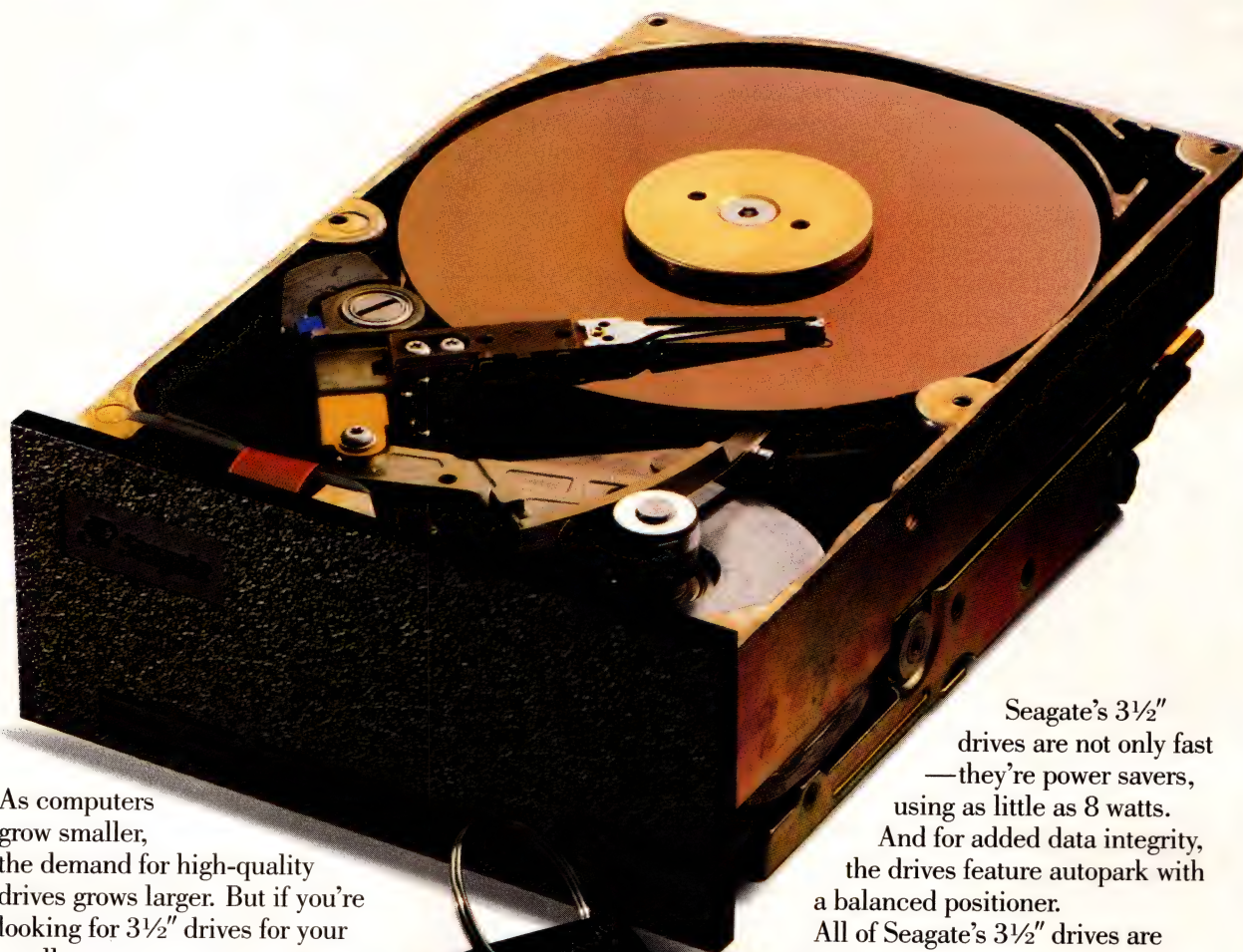


Fig 1—In this loop, the multiplexer selects a timing resistor for the timer, which clocks the counter, IC₂. The counter's resulting output-state durations depend on the values you select for resistors R_{T0} through R_{T7}.

NOW YOU CAN DRIVE OUR SUBCOMPACTS.

Seagate's family of 3½" hard disc drives.



As computers grow smaller, the demand for high-quality drives grows larger. But if you're looking for 3½" drives for your small computer systems, you don't have a lot to choose from.

Except at Seagate.

We offer six 3½" drives with 21, 32 and 48 MB formatted capacities. You also have a choice of interfaces: SCSI or ST412 with RLL or MFM encoding. All with 28 msec access time.

Our 3½" drives use Seagate's field-proven, proprietary stepper motors to achieve fast access times normally found only with more expensive voice coil actuators.

Seagate's 3½" drives are not only fast—they're power savers, using as little as 8 watts.

And for added data integrity, the drives feature autopark with a balanced positioner.

All of Seagate's 3½" drives are built with the precision and quality that have made us the world's leading independent manufacturer of 5¼" full-height and half-height hard disc drives.

Only Seagate has the worldwide, high-volume manufacturing efficiency to meet the growing demand for 3½" drives.

When you're ready to go for a little drive, give us a call. 800-468-DISC.



 **Seagate**

The first name in disc drives.

Reduce ac-coupled flip-flop's dissipation

Dan Awtry
Consultant, Garland, TX

Fast RC time constants can dominate power consumption in a conventional ac-coupled, RS flip-flop (**Fig 1a**). The 100-nsec components shown, for instance, dissipate 10 mW—more than twice the dissipation of two LSTTL gates. By simply reconnecting R_2 and R_4 , (**Fig 1b**), you can halve the circuit's power dissipation and obtain other benefits as well.

Fig 1b's resistor connections eliminate dissipation in the circuit's inactive RC network. When IC_{1a} 's pin-2 input is at logical zero, for instance, the dissipation in R_1 and R_2 is zero, because both ends of the resistors are at 5V. Meanwhile, the logical zero at IC_{1b} 's output allows current flow in R_3 and R_4 , producing 3V (logical one) at the pin-5 input. Applying a negative-going edge to C_2 toggles the flip-flop; then, a similar signal to C_1 will toggle the flip-flop again. Note that in each case, the inactive network pulls the gate voltage to V_{CC} (and away from the gate input's linear region, which would dissipate additional power).

R_2 and R_4 also serve as pullup resistors for the gate outputs, ensuring that logical-one outputs reach the V_{CC} level for active- or passive-pullup gates. You can build the circuit with active- or passive-pullup, TTL or CMOS 2-input NAND gates.

EDN

To Vote For This Design, Circle No 749

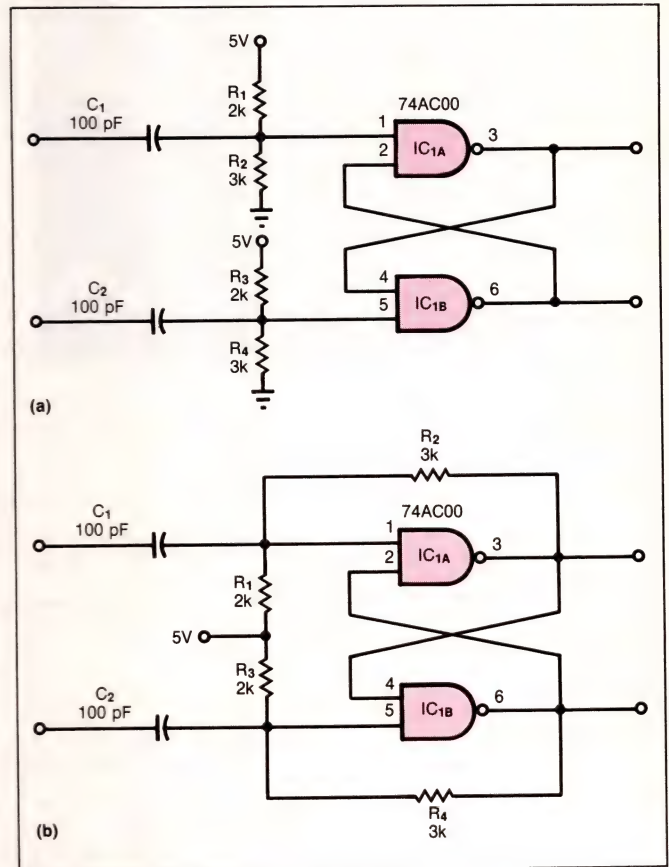


Fig 1—To halve the power dissipation in the conventional ac-coupled RS flip-flop (**a**), simply reconnect R_2 and R_4 as shown in **b**.

Swept amplitudes enhance signal generator

J Millar and T G Barnett
The London Hospital Medical College,
London, UK

Adding **Fig 1's** circuit to an existing waveform generator provides a swept-amplitude function. That is, the V_{OUT} amplitude changes by a fixed amount on alternate zero crossings and remains constant during each full cycle. For the connections shown, the successive cycles grow in this manner to a $\pm 10V$ maximum, return to a

$\pm 1V$ minimum, and repeat. This capability is useful for evaluating certain biomedical sensors and electrodes, for instance, which may exhibit voltage-dependent characteristics that other test methods don't reveal.

The circuit provides a frequency range of dc to 100 kHz while preserving other waveform capabilities the generator may have (waveform type, swept frequency, gated operation, etc). In short, the circuit uses an analog divider (IC_6) to divide V_{IN} by a constant whose value changes with each successive cycle.

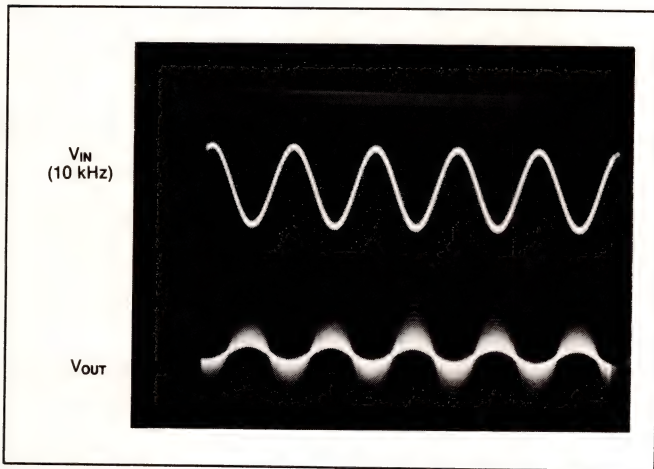
DESIGN IDEAS

Op amp IC₁, connected as a zero-crossing comparator, produces a square wave that is synchronous with the V_{IN} frequency. After being inverted by the

Schmitt-trigger gate (IC₂), this signal drives the clock input (pin 17) of the multifunction converter, IC₃. IC₃ includes an 8-bit D/A converter and an up/down counter configured to count up, reverse at full scale, then count down and reverse at zero, and so on. The counter's output drives the converter to produce a 0 to 9V staircase waveform at the output of amplifier IC₄. (Note that you can lower the staircase frequency by reducing IC₃'s clock rate. You can introduce a CD4040 binary counter between the timer and the converter, for example, to divide that signal by a suitable factor.)

The analog divider, IC₆, then divides successive V_{IN} cycles by successive discrete levels of the staircase waveform. Note that the divider and the op amps require ±15V supply voltages.

EDN



This output (from Fig 1) shows discrete levels which, for the 10-kHz V_{IN} shown, have a duration of 0.1 msec each.

To Vote For This Design, Circle No 747

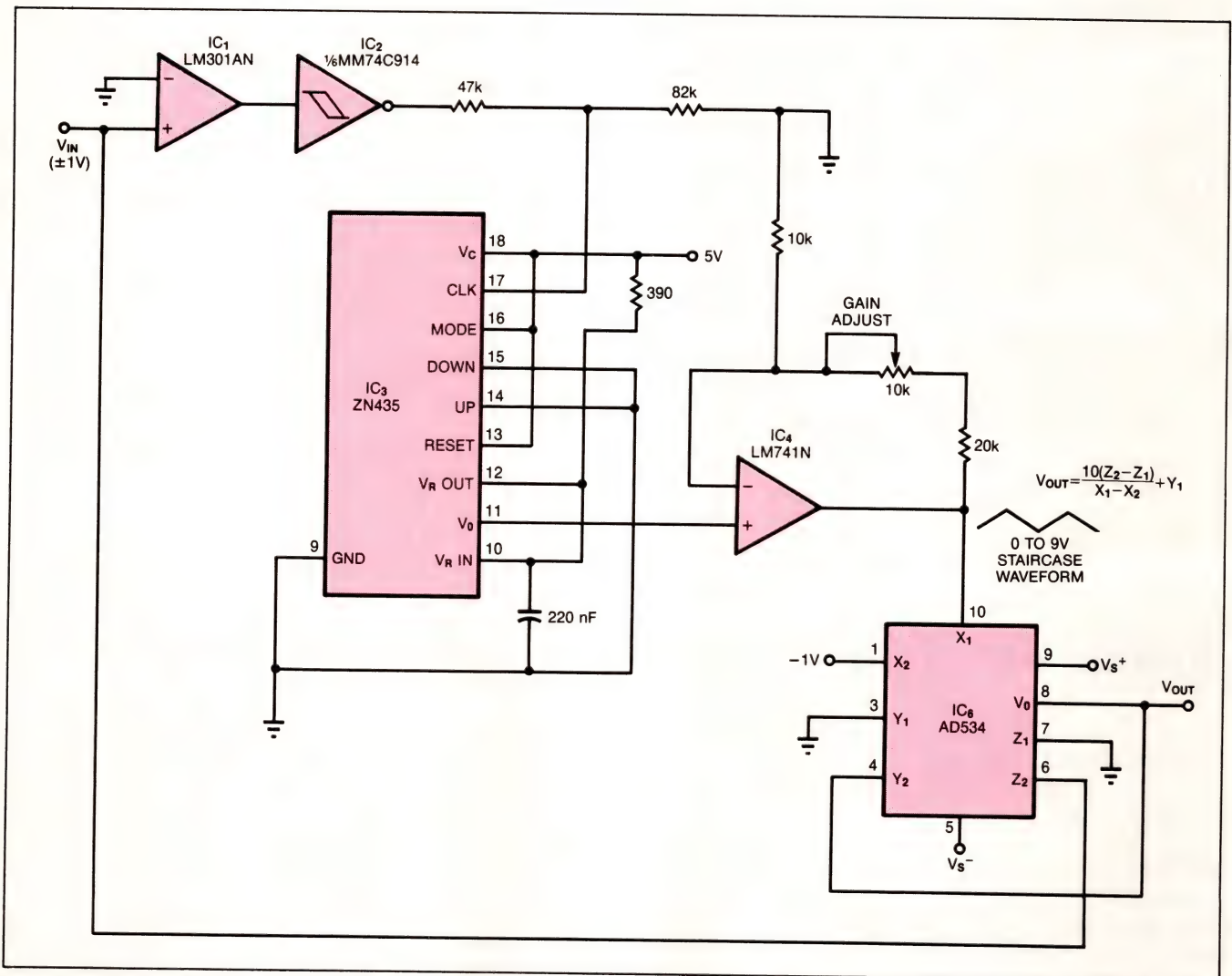


Fig 1—This circuit sweeps the amplitude of V_{IN} by providing discrete levels of gain for each successive cycle, in a staircase pattern.

tiny SPDT switches

absorptive... reflective

dc to 4.6 GHz from \$32⁹⁵ (1-24)

Tough enough to pass stringent MIL-STD-883 tests, useable from dc to 6GHz and smaller than most RF switches, Mini-Circuits' hermetically-sealed (reflective) KSW-2-46 and (absorptive) KSWA-2-46 offer a new, unexplored horizon of applications. Unlike pin diode switches that become ineffective below 1MHz, these GaAs switches can operate down to dc with control voltage as low as -5V, at a blinding 2ns switching speed.

Despite its extremely tiny size, only 0.185 by 0.185 by 0.06 in., these switches provide 50dB isolation (considerably higher than many larger units) and insertion loss of only 1dB. The absorptive model KSWA-2-46 exhibits a typical VSWR of 1.5 in its "OFF" state over the entire frequency range. These surface-mount units can be soldered to pc boards using conventional assembly techniques. The KSW-2-46, priced at only \$32.95, and the KSWA-2-46, at \$48.95, are the latest examples of components from Mini-Circuits with unbeatable price/performance.

Connector versions, packaged in a 1.25 x 1.25 x 0.75 in. metal case, contain five SMA connectors, including one at each control port to maintain 3ns switching speed.

Switch fast... to Mini-Circuits' GaAs switches.

SPECIFICATIONS

Pin Model	KSW-2-46	KSWA-2-46
Connector Version	ZFSW-2-46	ZFSWA-2-46
FREQ. RANGE	dc-4.6 GHz	dc-4.6 GHz
INSERT. LOSS (dB)	typ max	typ max
dc-200MHz	0.9 1.1	0.8 1.1
200-1000MHz	1.0 1.3	0.9 1.3
1-4.6GHz	1.3 1.7	1.5 2.6
ISOLATION (dB)	typ min	typ min
dc-200MHz	60 50	60 50
200-1000MHz	45 40	50 40
1-4.6GHz	30 23	30 25
VSWR (typ)	ON 1.3:1 OFF —	1.3 1.4
SW. SPEED (nsec) rise or fall time	2(typ)	3(typ)
MAX RF INPUT (bBm)		
up to 500MHz	+17	+17
above 500MHz	+27	+27
CONTROL VOLT.	-5V on, OV off	-5V on, OV off
OPER/STOR TEMP.	-55° to +125°C	-55° to +125°C
PRICE (1-24)	\$32.95 \$72.95	\$48.95 \$88.95

finding new ways...
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

CIRCLE NO 87

C 117 REV. D

Design Entry Blank

\$75 Cash Award for all entries selected by editors. An additional **\$100 Cash Award** for the winning design of each issue, determined by vote of readers. Additional **\$1500 Cash Award** for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor, EDN Magazine
Cahners Publishing Co
275 Washington St, Newton, MA 02158

I hereby submit my Design Ideas entry.

Name _____

Title _____ Phone _____

Company _____

Division (if any) _____

Street _____

City _____ State _____ Zip _____

Design Title _____

Home Address _____

Social Security Number _____
(Must accompany all Design Ideas submitted by US authors)

Entry blank must accompany all entries. Design entered must be submitted exclusively to EDN, must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed _____

Date _____

Your vote determines this issue's winner. All designs published win \$75 cash. All issue winners receive an additional \$100 and become eligible for the annual \$1500 Grand Prize. **Vote now**, by circling the appropriate number on the reader inquiry card.

ISSUE WINNER

The winning Design Idea for the February 18, 1988, issue is entitled "Derive $\pm 15V$ and $5V$ from a $12V$ battery," submitted by Andy Jenkins of Maxim Integrated Products (Sunnyvale, CA).

Alterable code enhances instructions

Noor Singh Khalsa
EG&G Inc, Los Alamos, NM

By using a static RAM with built-in battery backup, you can create self-modifying code that enhances the instruction set of your μP . The 8031, for example, has a built-in bit map, but you must address the bits directly. A few instructions (**Fig 1**) let you implement an indexed addressing scheme that dynamically alters the second byte of the bit-addressing instruction (which is the bit's address).

EXAMPLE:		; implementing MOV C,
	MOV DPTR,#INSTR+1	; point to bit address
	MOVX @DPTR,A	; set address
INSTR:	MOV C,0	; this is the modified instruction
	RET	

Fig 1—You can use these instructions to implement an indexed addressing scheme that dynamically alters the second byte of the 8031's bit-addressing instruction.

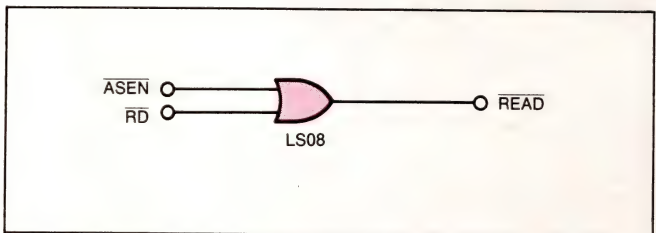


Fig 2—This external OR gate causes a complete overlap in the 8031's otherwise separate 64k-byte memory spaces for code and data.

The 8031 maintains a separate memory space for code and data. The **Fig 1** scheme, however, requires that you combine these memory spaces by making them overlap. To do so, you simply OR the instruction-fetch signal (PSEN) with the external-memory read signal (RD) as shown in **Fig 2**. This circuit reduces the total memory space to 64k bytes (instead of 64k bytes each for code and data), but you gain the programming advantage of being able to mix the MOVX and MOVC instructions. For example, you can eliminate a CLR A instruction by using MOVX A,@DPTR instead of the MOVC a,@A+DPTR instruction.

EDN

To Vote For This Design, Circle No 746

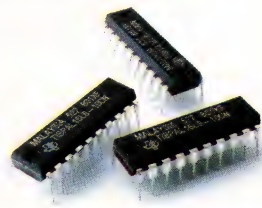
"First universal circuit design I've seen...too bad it only runs at half-warp speed."



TI Programmable-array Logic devices direct to you from the Hall-Mark IMPACT™ Design and Services Center.

Hall-Mark has a way to give your designs more performance. Economically. Quickly and easily. Hall-Mark can deliver the TI IMPACT PAL® family and help you get your product to market faster.

Whether you want TI PAL devices to program yourself or choose to use the Hall-Mark/Texas Instruments IMPACT Design and Services Center, you get the benefits of enhanced speed in your critical paths such as control logic, address decoding and sequence generation.



Hall-Mark can show you how to use the fastest family of bipolar PAL circuits in the industry today to gain new speed in your designs. The TI family also includes the fastest standard 22V10-family device available today: the TIBPAL22VP10-20. It is pin-compatible with slower, competitive 22V10 devices.

Now's the time to come up to speed with Texas Instruments IMPACT PAL devices from Hall-Mark. Give your Hall-Mark salesperson a call right now.



Hall-Mark Electronics Corp. • Dallas, Texas • Subsidiary of Tyler Corp.

We deliver on Texas Instruments Technology.

Alabama
Huntsville (205) 837-8700
Arizona
Phoenix (602) 437-1200
California
Bay Area (408) 432-0900
Orange County (714) 669-4100
Sacramento (916) 722-8600
San Diego (619) 268-1201
San Fernando Valley (818) 716-3300
West Los Angeles (213) 217-8400

Colorado
Denver (303) 790-1662
Connecticut
Connecticut (203) 269-0100
Florida
Ft. Lauderdale (305) 971-9280
Orlando (305) 855-4020
Tampa Bay (813) 855-5773
Georgia
Atlanta (404) 447-8000
Illinois
Chicago (312) 860-3800

Indiana
Indianapolis (317) 872-8875
Kansas
Kansas City (913) 888-4747
Maryland
Baltimore (301) 988-9800
Massachusetts
Boston (617) 935-9777
Michigan
Detroit (313) 462-1205
Minnesota
Minneapolis (612) 941-2600

Missouri
St. Louis (314) 291-5350
New Jersey
Fairfield (201) 575-4415
New York
Long Island (516) 737-0600
Rochester (716) 244-9290
North Carolina
Raleigh (919) 872-0712
Ohio
Cleveland (216) 349-4632
Southern Ohio (614) 888-3313

Oklahoma
Tulsa (918) 251-1108
Pennsylvania
Philadelphia (215) 355-7300
Texas
Austin (512) 258-8848
Dallas (214) 553-4300
Houston (713) 781-6100
Utah
Salt Lake City (801) 972-1008
Wisconsin
Milwaukee (414) 997-7844



TM/IMPACT is a trademark of Texas Instruments Incorporated.

* PAL is a registered trademark of Monolithic Memories, Inc.

© 1988 Hall-Mark Electronics Corp./400-3008

CIRCLE NO 88

Introducing The World's Most Advanced Power Supply Control IC.

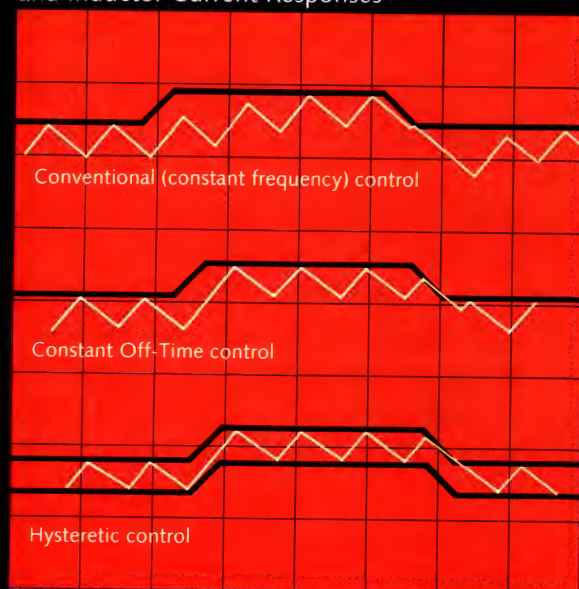
The CS-320 from Cherry Semiconductor Corporation

The CS-320. A power supply control IC so advanced it is the first to provide for unconditionally stable Hysteretic control.

The CS-320. A power supply control IC so advanced it is the world's first to offer power supply designers the option of working in any one of three modes of control: Hysteretic, Constant-Off-Time or Conventional (constant frequency).

The CS-320. A power supply control IC so advanced it offers better short circuit protection than any other control chip in the world.

Load Current Demand and Inductor Current Responses



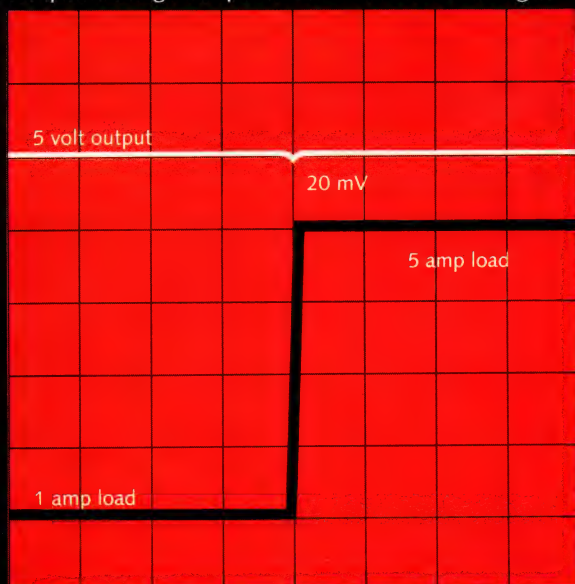
Three Types of Control

The CS-320 offers power supply designers greater range and flexibility. While conventional control can be used, Hysteretic and Constant-Off-Time are both superior. Conventional control does **not** instantaneously respond to load current demand. Hysteretic and Constant-Off-Time control, by comparison, **do** provide instantaneous response, which guarantees that the power supply will remain well-controlled and stable.

CSC CHERRY SEMICONDUCTOR

Cherry Semiconductor Corp., 2000 South County Trail, East Greenwich, RI 02818
(401) 885-3600 FAX (401) 885-5786 Telex: WUI6817157

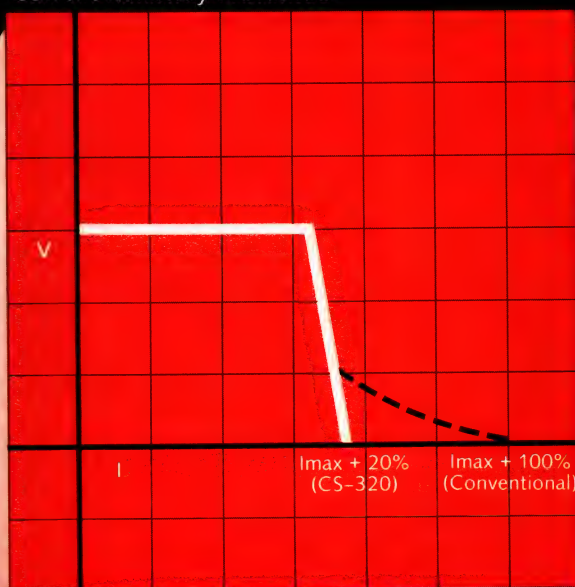
Output Voltage Response to a 5:1 Load Change.



Unconditional Stability.

Hysteretic control directly controls both the peak and valley inductor current. Additionally, slope compensation is not required. A power supply using Hysteretic control is free from subharmonic oscillation and is unconditionally stable. Figure 2 shows the response of a CS-320 controlled Hysteretic DC-DC converter to a 5:1 variation in load current.

Current Runaway Prevented



Unconventional Control of Short Circuits

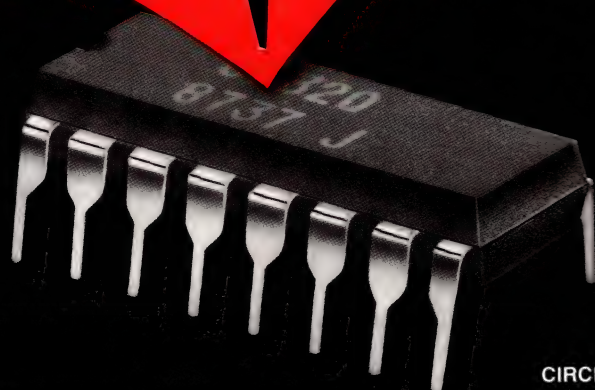
The unique (patent pending) circuitry of the CS-320 prevents current runaway at or near short circuit conditions during high frequency operation.

All of these advances can be working for you, plus operation at up to 1MHz, flexible current sensing, use in parallel operation of converters without master/slave designation, and Under Voltage Lockout with a choice of start/stop thresholds.

Excellent Application Support

Cherry Semiconductor is a leading producer of power supply control ICs. In addition to product innovation, CSC is recognized for helping customers to anticipate problems, arriving at workable solutions, and effectively integrating CSC ICs into end product designs.

Call or write for more information.



Aeroflex announces the new math for MIL-STD-1553 design engineers.

In which three goes into one just once.

1.

Low power dual redundant transceivers

2.

Dual decoder, encoder and protocol processor for Remote Terminal, Bus Controller and Bus Monitor

3.

Dual port RAM with 8K words of memory and full memory management

You are looking at the most powerful, flexible and unique MIL-STD-1553B interface currently available. Bar none.

Now, in one 2 x 3.1" package, this new ARX 2427 Universal Bus Interface Unit (UBIU) combines all the functions it takes three competitive hybrids to perform. Fact is, of all hybrids today, only the ARX 2427 reduces interface and hardware time to absolute zero.

The powerful ARX 2427 contains a dual port RAM that's double-sided and double-buffered to eliminate contention problems and wait states. Data can be mapped into RAM blocks by subaddress or alternately stacked. Memory is accessed for read and write using address lines and a select line, treated as subsystem memory. The host system is therefore freed from critical

timed response to Bus traffic and communication overhead is kept to a bare minimum. The unit also includes extensive error checking, which eliminates handling bad data. Fault monitoring plus many other features make the ARX 2427 clearly the most useful of 1553 interfaces.

So forget complex interconnect schemes. Forget special glue logic circuitry design

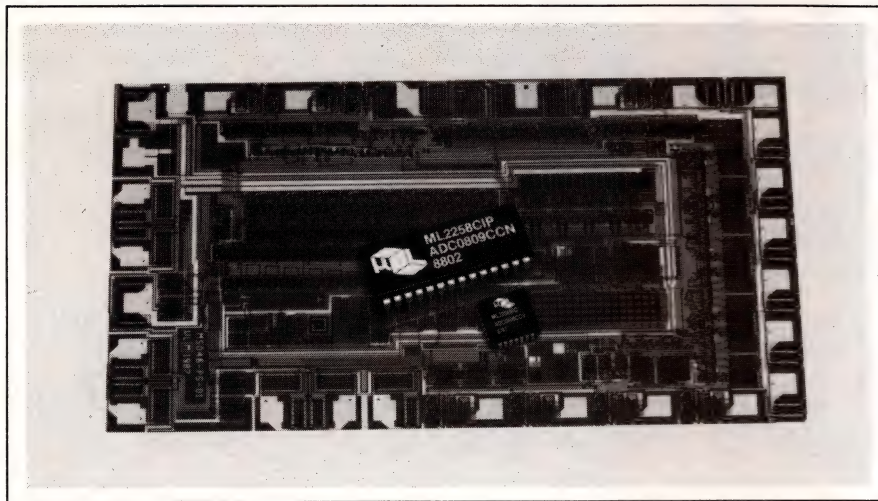
for subsystem compatibility. Forget using up valuable PC board real estate. The ARX 2427 is the UBIU to remember when you want to solve your 1553 problems—once—and for all.

For additional information call toll-free: 1-800-THE-1553 or TWX 510-224-6417. Or write Aeroflex Laboratories Inc., Microelectronics Division, 35 South Service Road, Plainview, NY 11803.



NEW PRODUCTS

INTEGRATED CIRCUITS



8-BIT ADC

- Features 6.6- μ sec conversion rate
- Includes 8-channel multiplexer

Designed for μ P-based applications, the ML2258 is an 8-bit, SAR-type A/D converter, with a built-in 8-channel multiplexer. The on-chip sample-and-hold function features a 375-nsec acquisition time and, combined with the ADC's 6.6- μ sec conversion rate, enables the device to digitize a 50-kHz, 0-to-5V sine wave with less than -60 dB of harmonic distortion. The ML2258 is a pin-

compatible, enhanced alternate-source for the industry-standard ADC0808 and ADC0809. The μ P interface of the ML2258 operates asynchronously to the converter clock, allowing the μ P to utilize the A/D converter's speed while saving hardware and program space. The ML2258 operates from a 5V supply and has an analog input range of 0 to 5V. In 28-pin DIP, \$3.35; in 28-pin PLCC, \$3.95 (100).

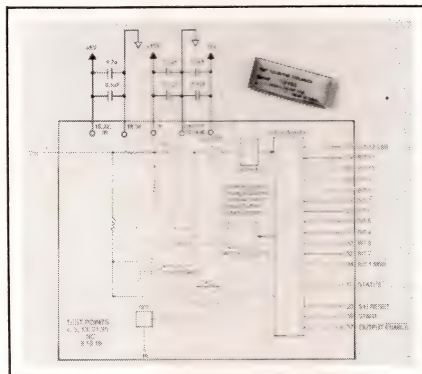
Micro Linear Corp., 2092 Concourse Dr, San Jose, CA 95131. Phone (408) 262-5200.

Circle No 351

A/D CONVERTERS

- 500-nsec conversion speed
- Choice of input range

Combining thick- and thin-film hybrid technology, the 4192, 4193, and 4195 12-bit A/D converters feature a maximum conversion speed of 500 nsec. The 4192 has selectable input ranges of 0 to 10V, 0 to 20V, and ± 10 V. The 4193 has an input range of 0 to 5V, and the 4195 has an input range of ± 2.5 V. The 4192 is a plug-in replacement for the Datal (Mansfield, MA) ADC500/505; the 4193 and 4195 are plug-in, higher-speed replacements for the MicroNetworks (Worcester, MA)

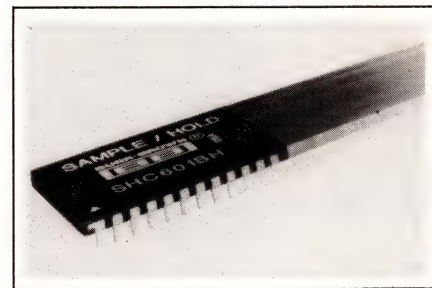


MN5345/46. By using this company's 4860 track/hold amplifier with the 4192/93/95 devices, you can achieve a digitizing rate of more than 1.3M sample/sec. All these devices have a typical power dissipa-

tion of 1.72W. The 4192 is housed in a 32-pin, triple-width hermetically-sealed ceramic package. The 4193 and 4195 are housed in 40-pin, dual-width hermetically-sealed ceramic packages. The devices are specified for operation over the 0 to 70°C and -55 to +125°C temperature ranges. MIL-STD-883B/S screening is also available. \$382 to \$489 (100).

Teledyne Philbrick, 40 Allied Drive, Dedham, MA 02026. Phone (617) 329-1600.

Circle No 352



S/H AMPLIFIER

- 100-MHz sample rate
- 115-MHz analog bandwidth

Designed for use in high-speed, 12-bit data-acquisition and signal-processing systems, the SHC601 S/H amplifier combines a 100-MHz sampling rate with high accuracy and low distortion. Linearity error is $\pm 0.02\%$ max, and harmonic distortion is -55 dB at 20 MHz. When used with flash A/D converters, the SHC601 significantly improves the signal-to-noise performance of these circuits. The amplifier acquires 2.5V input step changes to 0.1% accuracy in 12 nsec, has a slew rate of 350 V/nsec, and an analog bandwidth of 115 MHz. The device comes in a 24-pin ceramic DIP and has a specified temperature range of -25°C to +85°C. \$392.50 (100).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 353

Text continued on pg 218

MILITARY 16-BIT A/D's FIRST IN THEIR CLASS

MIL-STD-1772 CERTIFIED

MN5295/MN5290 & MN6290

High Speed:

MN5295: 17 μ sec Max. Conversion Time

MN5290: 40 μ sec Max. Conversion Time

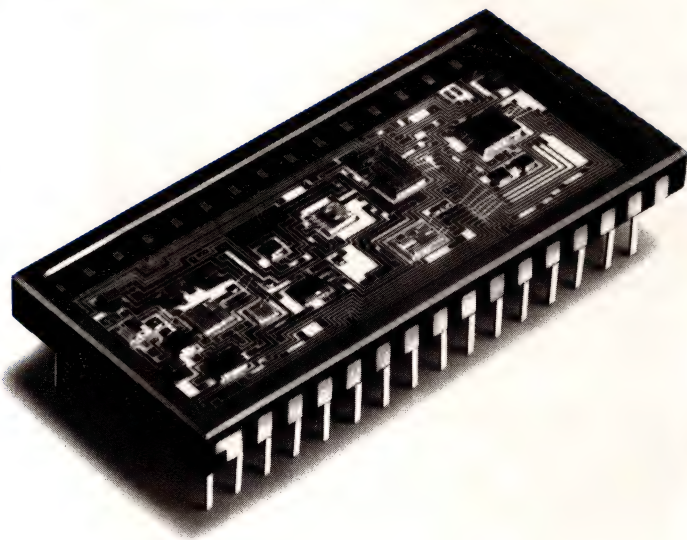
MN6290: 20kHz Min. Sampling Rate

Small 32-Pin Double-Wide DIP

14-Bit "No Missing Codes"

-55°C to +125°C Operation

MIL-STD-883 Screening



In the two speed classes of 16-bit A/D's that have emerged, only one supplier designs its devices to meet all of your military and aerospace requirements: Micro Networks.

In the high-speed (15-20 μ sec) class, our MN5295/96 are the fastest (17 μ sec), smallest (by 31%), and *only* devices to offer -55°C to +125°C operation and MIL-STD-883 screening.

In the general-purpose (40-50 μ sec) class, our MN5290/91 offer these same advantages; while our MN6290/91 add an internal T/H, plus FFT testing for improved performance, ease of specification, and significant space savings.

And most critical to your designs, these are the *only* devices that operate over the extended military temperature range with full military screening.

MN5295/MN5296

The newest in our expanding line of high-performance, military, 16-bit A/D's are at the top of their class.

Fastest Conversion Time:

17 μ sec Max. (16 Bits)

Smallest Package by 31%:

Double vs. Triple DIP

Widest Temperature Range:

-55°C to +125°C

Only Devices Available with 883 Screening

In the top speed class, our MN5295/96 excel, providing outstanding 16-bit performance in a DIP package that is fully 31% smaller than any competitor's. No other supplier can meet your requirements for high-speed, high-resolution, military A/D's. When your design demands the best, demand Micro Networks MN5295/96.

MN5290/MN5291

They're the best in their speed class of workhorse 16-bit A/D's. Specify them for all your applications that don't require the added performance of our MN5295/96.

Fastest Conversion Time in Their Class:

40 μ sec Max.

Smallest Package by 31%:

Double vs. Triple DIP

Widest Temperature Range:

-55°C to +125°C

Only Devices Available with 883 Screening

Like our MN5295/96, our MN5290/91 A/D's are ideal for any design where you need true 14 or 13-bit performance over an extended temperature range. These devices were the first 16-bit military A/D's. Since their introduction, their broad acceptance and proven performance have made them industry standards.

MN6290/MN6291

In a class by themselves, these FFT-tested sampling A/D's are ideal for traditional data acquisition and DSP applications.

Single Package Sampling A/D

High Resolution/Sampling Rate:

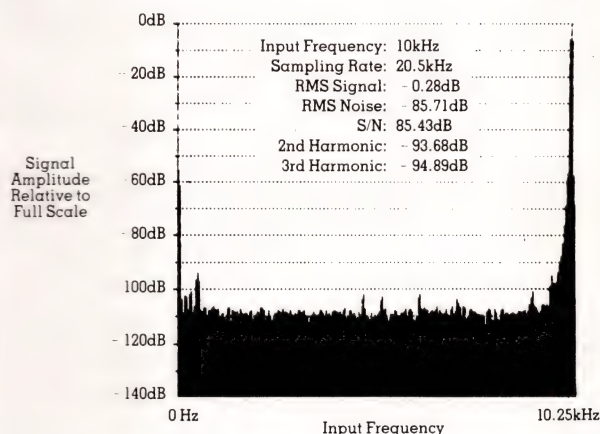
16 Bits @ 20kHz

Signal-to-Noise Ratio: 84dB

Harmonics: -88dB

Temperature Range: -55°C to +125°C

Available with MIL-STD-883 Screening



These devices eliminate the hassle of evaluating T/H specs that are difficult to understand and often don't relate.

For more detailed information, send for our comprehensive data sheets. For rapid response, call Russ Mullet at Ext. 208.

Micro Networks
324 Clark Street
Worcester, Massachusetts 01606
(617) 852-5400

Micro Networks
Advancing Data Conversion
Technology

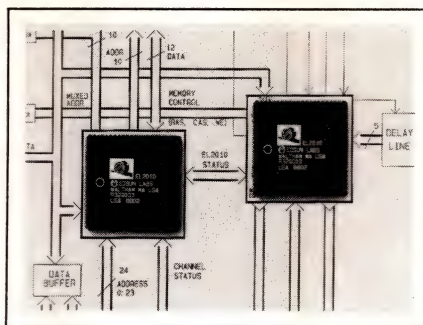
 **Micro Networks**
A DIVISION OF **UNITRODE** CORPORATION

Regional Sales Offices: Worcester, MA (617) 852-5400; Dallas, TX (214) 991-8566; Santa Ana, CA (714) 261-5044.

MEMORY INTERFACE

- 2-chip interface set for memory boards
- LIM-EMS 4.0 and OS/2 compatible

The EL2010 2-chip set provides the Micro Channel interface for memory boards used with the IBM PS/2 Models 50 and 60. The chips support



memory to 14.25M bytes and are compatible with the LIM-EMS 4.0 memory standard. The EL2010 includes a full set of power-on setup registers, selectable ID codes, parity logic, RAM control, and decoding for one parallel port and two serial ports. The chip set can function in systems operating to 16 MHz and can replace as many as 30 ICs. Implemented in low-power CMOS, the EL2010 chips come in 84-pin plastic leaded chip carriers. The 2-chip set, \$35 (1000).

Edsun Laboratories Inc., 9 Spring St, Waltham, MA 02154. Phone (617) 647-9300. TLX 853664.

Circle No 354

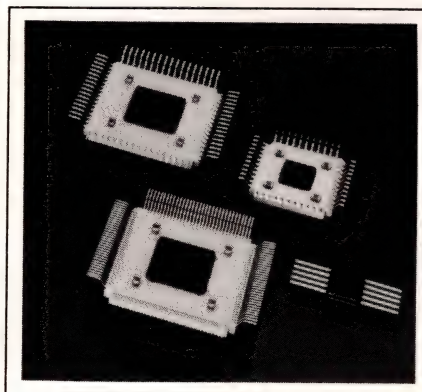
Let POMONA hand you the very best quality.

Oscilloscopes can cost up to \$10,000 or more, while its interconnecting test accessories amount to a minor purchase. So it just doesn't make good sense to buy cut-rate imitations that could put your test results in jeopardy. Since you want accurate readings, insist on the most reliable test products: POMONA.



For your FREE 1988 General Catalog, circle reader service number printed below

POMONA
ITT Pomona Electronics



GaAs STANDARD CELLS

- 6000 equivalent gates
- Toggle rates as high as 2 GHz

Fabricated in a gallium arsenide enhancement/depletion process, the QLSI standard-cell family supports LSI applications for as many as 6000 equivalent gates. The device's toggle rates, as high as 2 GHz, are two to three times faster than those of most bipolar silicon gate arrays. Two FET logic families are available: the ZFL and the SCFL cell families. The ZFL cells are similar to those used in the company's TQ3000 LSI gate array, which provides low-power gates capable of high fan-out at toggle rates reaching 1 GHz. The differential current-switched SCFL cells are similar to silicon ECL logic, but have toggle rates as high as 2 GHz. The ability of the SCFL cells to operate from a

Text continued on pg 226
EDN May 12, 1988

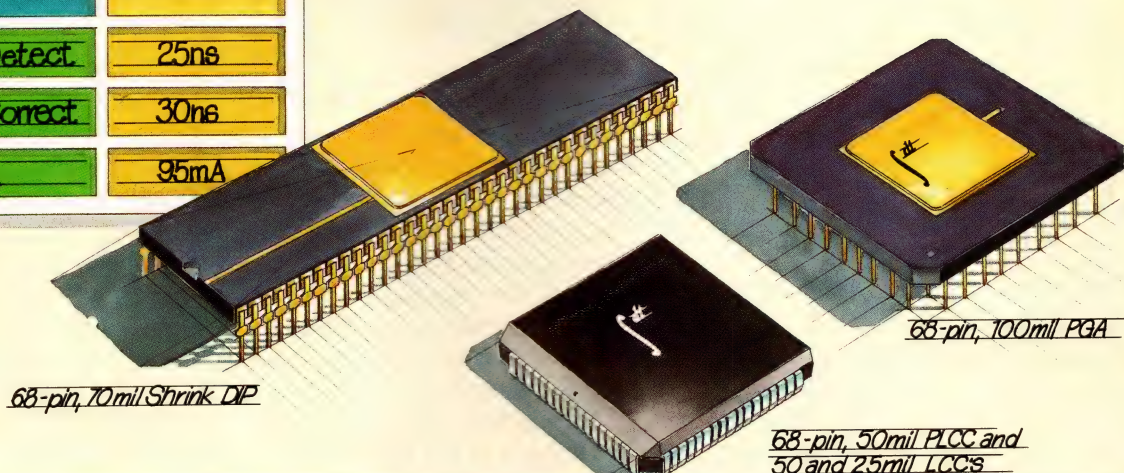
World's Fastest

32-bit CMOS EDC

25ns | DETECT TIME

FASTEST SPEED/LOWEST POWER

	IDT 49C460B
Data to Error Detect	25ns
Data to Error Correct	30ns
Commercial I _{cc}	95mA



IDT49C460B: fastest speed, lowest power 32-bit EDC.

Your memories are getting bigger and with that comes higher error rates. Use the new, faster **IDT49C460B** to enhance data integrity. It corrects all single-bit errors, detects all double and some triple-bit errors.

Replaces 2960s. You can easily upgrade existing 2960 systems with the IDT49C460B because both devices use the same Hamming code. Your design benefits from faster speed, improved power consumption and a 3-to-1 reduction in chip count. Byte writes, byte operations and diagnostics are included.

Faster than bipolar. The IDT49C460B detects an error in 25ns and corrects in 30ns. Nothing is faster.

Lowest power. The only 32-bit EDC in CMOS consumes just 95mA commercial. Now you can get EDC faster than the fastest bipolar but with CMOS power.

Cascades to 64 bits. Only IDT offers you a simple, two chip solution for 64-bit EDC. (The TI632 cannot be cascaded to 64-bits; while the Am2960 approach requires 14 devices.)

16-Bit EDC

	IDT39C60A	IDT39C60-1	IDT39C60
Data to error detect	20ns	25ns	32ns
Data to error correct	30ns	52ns	65ns
Commercial I _{cc}	85mA	85mA	85mA

Speed leadership in 16-bit EDC.

We also make a family of 16-bit CMOS EDCs. All are 2960 pin compatible with improved output drive while consuming only 1/4 the power.

The **IDT39C60A** is unquestionably the highest performance TTL compatible CMOS 16-bit EDC in the world. And more than just some "specs on paper," it's available now—in volume.

The **IDT39C60-1** and **IDT39C60** are equal in speed to both the 2960-1 and 2960.

Packages. □ 48-pin plastic and ceramic DIPs. □ 52-pin PLCC/LCCs.

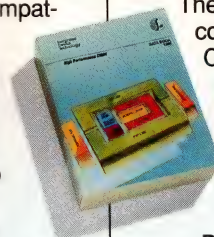
Cascadable. Up to 64 bits.

Ask for your FREE Data Book!

Everything you want to know about cool and fast EDC is in our new, 1800 page **1988 DATABOOK**. Call your local IDT representative or **(408) 492-8314** and ask for your FREE copy.

The DATABOOK also contains complete information on our CMOS Static RAMs • specialty memory products such as FIFOs and DUAL-PORTs • ultra-fast RISC processors and bit-slice ALUs • Multiplier-Accumulators and Floating-Point Processors • TTL logic

- Data Conversion products
- ECL Interface products.



3236 Scott Blvd.
Santa Clara, CA 95054-3090
(408) 492-8314
FAX: 408 727-2328

single 5V supply provides compatibility with existing silicon-based logic. The QLSI standard-cell ICs are available in both die and packaged form. Nonrecurring engineering charges start at \$60,000 and include design manuals and workstation software. Delivery, 16 weeks ARO.

TriQuint Semiconductor Inc., Group 700, Box 4935, Beaverton, OR 97076. Phone (503) 641-4227.

Circle No 355

SCSI CONTROLLER

- 4M-bytes/sec transfer rate
- Asynchronous SCSI interface

Reportedly twice as fast as the industry-standard 53C80 chip, the pin-compatible L53C80 can transfer data as fast as 4M-byte/sec. The L53C80 also corrects a problem in the original device that prevented designers from using the block-



mode DMA feature in new designs. The L53C80 also satisfies the SCSI asynchronous interface as defined by the ANSI X3T9.2 committee, and extends the range of this 2M-byte/sec standard. The device's built-in drivers handle 48 mA of current and connect directly to the SCSI cable. The power consumption of the L53C80 is 15 mW (5V at 15 mA). The device is available in a 48-pin DIP or a 44-pin plastic leaded chip carrier. In plastic DIP, the

L53C80PC-2 costs \$6.65; the L53C80PC-4 is \$9 (100).

Logic Devices Inc., 628 E Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630.

Circle No 356

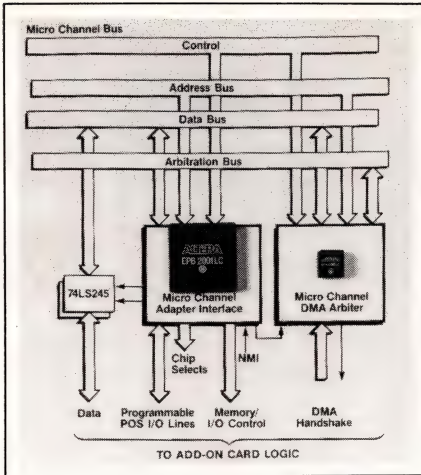
INTERFACE CHIP

- For Micro Channel add-on boards
- User-configurable programming

Designed for add-on boards for the IBM PS/2 personal computers, the EPB2001 user-configurable interface chip allows board manufacturers to program the chip for board ID and address ranges, which are essential requirements of the Micro Channel specifications. Built from EPROM technology, the EPB2001 incorporates high-current bus drivers and does not need external chips or jumpers to provide the Micro Channel interface. The device meets

Color by

 Apollo brightens existing Domain® systems with an upgrade to display 256 colors from a 16.8 million color palette. Brooktree® brightened Apollo's day with the RAMDAC that makes that palette economical.



all ac-timing and dc-drive requirements without any additional buffer components. The EPB2002 DMA arbitration chip works with the EPD2001 interface chip to integrate the additional logic required for DMA capability. The EPB2001 comes in a windowed 84-pin, J-lead surface-mount package and a windowless, 1-time programmable device. The EPD2002 comes in a

28-pin DIP and a 28-pin J-lead package. \$12 (EPD2001); \$5 (EPD2002) (10,000). Samples will be available this quarter; production of both versions is scheduled for the second half of 1988.

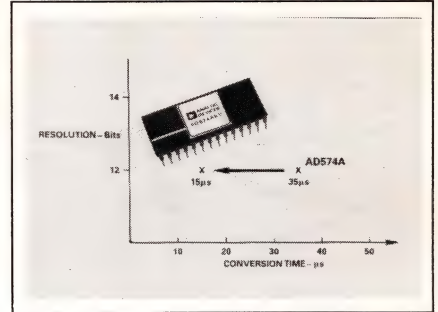
Altera Corp., 3525 Monroe St., Santa Clara, CA 95051. Phone (408) 984-2800.

Circle No 357

12-BIT ADC

- 15- μ sec conversion time
- 150-nsec data-access time

The AD674A 12-bit A/D converter is pin-compatible with the AD574 but features a 15- μ sec conversion time. It has 3-state buffers, a maximum data-access time of 150 nsec, and interfaces to most digital processors. The converter can read data as one 12-bit word or as two 8-bit bytes. Typical operation is under μ P control, but you can also



implement a stand-alone mode. Specified for use with either $\pm 12V$ or $\pm 15V$ supplies, the AD674A provides 4 signal-input ranges of 0 to 10V and 0 to 20V (unipolar), and $\pm 5V$ and $\pm 10V$ (bipolar). The device includes an internal buried-zener reference trimmed to 10V, which can drive external loads to 2 mA. The AD674A is available in 6 grades starting at \$39.25 (commercial) and \$107.25 (military) (100).

Analog Devices, Literature Center, 70 Shawmut Rd., Canton, MA 02021. Phone (617) 935-5565.

Circle No 358

Brooktree®



Brooktree Bt458. Triple 8-bit color RAMDAC. Available in speeds from 75 MHz to 135 MHz.

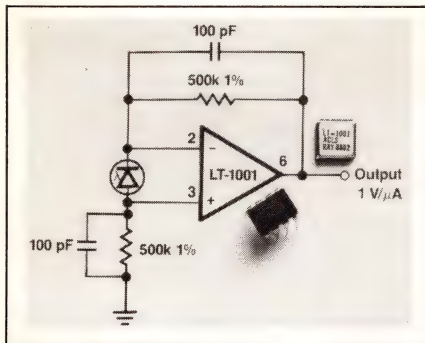
Colorboard upgrade for Apollo DN3000 and DN4000 Domain Systems. Provides 1024 x 800 screen resolution. Displays 256 colors from 16.8 million color palette.

Brooktree Corporation, 9950 Barnes Canyon Road, San Diego, California 92121. 1-800-VIDEO IC or 1-800-422-9040, in California.

Apollo and Domain are registered trademarks of Apollo Computer Inc. © Copyright Brooktree Corporation 1987



INTEGRATED CIRCUITS



PRECISION OP AMP

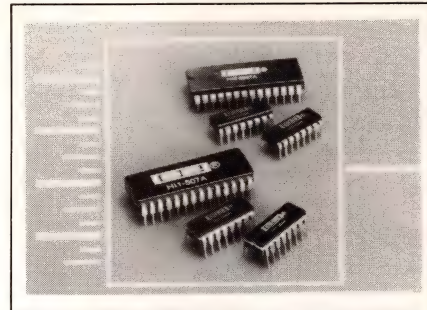
- 15- μ V offset voltage
- High CMRR and PSRR

The LT1001 precision op amp features a maximum offset voltage of 15 μ V and a maximum offset drift of 0.6 μ V/ $^{\circ}$ C. It's offered as a true second source to the industry part bearing the same designation. The device also features a maximum input-bias current of 2 nA, a CMRR of 114 dB, and a PSRR of 110 dB. Input noise is 0.6 μ V p-p from 0.1 to 10 Hz. Maximum power dissipation

is 75 mW. Package options for the LT1001 include SOIC, PLCC, TO-99, and ceramic and plastic DIPs. From \$1.10 (100).

Raytheon Co., 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211.

Circle No 359



ANALOG MULTIPLEXERS

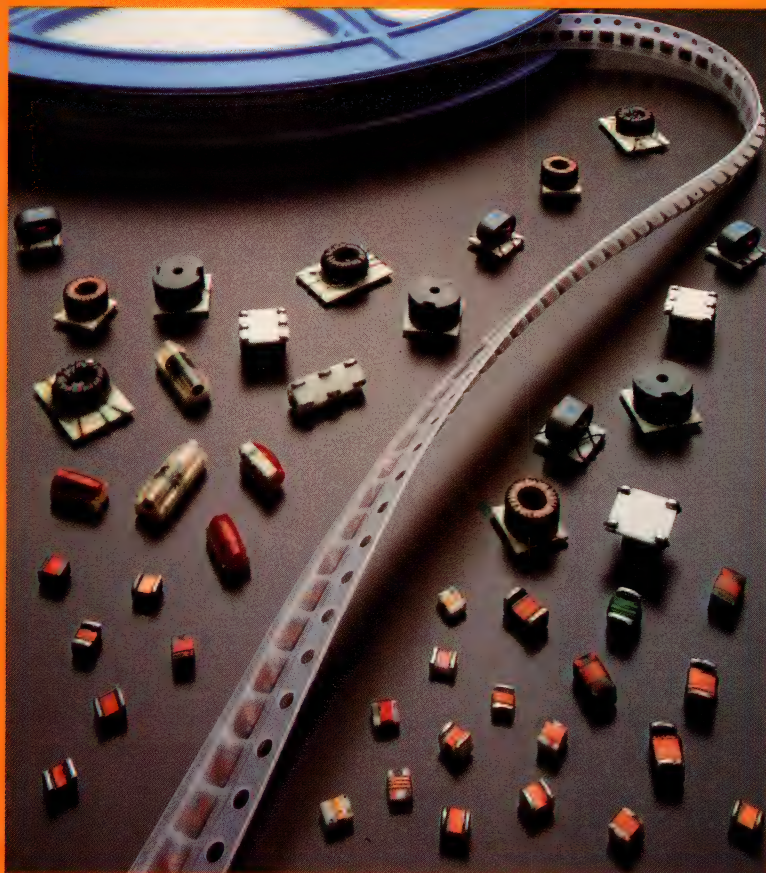
- Single-ended or differential
- Offers versions having between 4 and 16 channels

Fabricated in CMOS, the HI-506A, HI-507A, HI-508A, and HI-509A are analog multiplexers that have transfer accuracies of better than 0.1% at sampling rates to 200 kHz. The analog inputs of the devices can withstand an overvoltage to 70 V p-p, and feature break-before-make switching. The HI-506A provides 16 single-ended channels; the HI-507A, 8 differential channels; the

HI-508A, 8 single-ended channels; and the HI-509A, 4 differential channels. The input signal range for all channels of all devices is ± 15 V, and crosstalk is limited to 0.005% of the voltage level when the channel is off. The multiplexers are packaged in ceramic or plastic DIPs, specified for 0 to 75 $^{\circ}$ C or -55 to +125 $^{\circ}$ C. Prices start at \$13.50 for the HI-506A/HI-507A, and \$7.35 for the HI-508A/HI-509A (100).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 360



Coilcraft is big in small inductors

Call Coilcraft for all your surface mount inductors—fixed, tuneable, transformers, or toroids.

Most are in stock, ready for immediate shipment. And all are priced incredibly low, even in small quantities.

To help you get started, we've prepared Experimenter's Kits with dozens of our most popular values.

For complete specifications, or to order your kits, call 312/639-6400.

Experimenter's Kits

Fixed Inductor Kit CI100—\$125
4 nH—1,000 μ H, 64 values (6 of each)
Tuneable Inductor Kit CI101—\$50
100 nH—10 μ H, 11 values (5 of each)



Coilcraft

1102 Silver Lake, Cary, IL 60013

312/639-6400

3C85 Power Material

Precise from the start.
Guaranteed to the
finish.

It's true. And tried. And available right now.

A ferrite material with tight, guaranteed specifications that extend even to the finished component. Pretty extraordinary, but then so is our 3C85.

There's no learning curve. No trial and error. Over an arduous three year development period, it was tested, refined and retested—made ready, at last, for our spectacular new processing kiln—a technological wonder in itself. The result is amazing batch-to-batch consistency that traditional tunnel kilns can't hope to match.

And performance is prolific. Compared to our own 3C8, this dramatic new material delivers a 30%-plus loss improvement. Which means you can use a smaller

core to do the same work or get more out of a given core size. Either way, you can count on proven results from start to finish.

To get your copy of our components specifications, contact Ferroxcube at 914-246-2811. You'll find 3C85 components to be precisely as we have specified. Guaranteed.



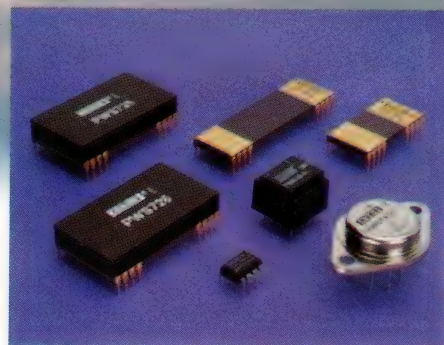
FERROXCUBE
A Material Difference.

Division of Ampere Electronic Corporation
A North American Philips Company
5083 Kings Highway, Saugerties, NY 12477
914-246-2811 TWX: 510-247-5410

SIMPLE, LOW-COST ANALOG ISOLATION

SIGNAL

POWER



NEW SIGNAL AMPLIFIERS AND POWER CONVERTERS GIVE YOU COMPLETE, GUARANTEED ISOLATION SOLUTIONS.

When you need to protect low-level analog signals from noise or high-voltage potentials, choose the industry's most advanced isolation solutions.

Easy-to-use, hermetic isolation amplifiers.

The patented capacitive ceramic isolation barrier of Burr-Brown's unique ISO102/106 buffer amps provides superior protection at extremely low cost:

- 1500Vrms or 3500Vrms isolation voltages, 100% tested and guaranteed;
- industry's first hermetic isolation amps;

Economical, isolated DC/DC converters.

PWS725/726 converters supply isolated, ± 7 -to-18VDC, 40mA outputs from single 7-18V supplies. Use them with ISO102/106 amps for complete, low-cost systems:

- 1500Vrms or 2500Vrms isolation voltage protection;

New distributed power system delivers lowest isolation cost-per-channel.

PWS740 modular DC/DC converter systems save board space and minimize multichannel isolation costs. Compact driver, transformer, and

rectifier components provide 30mA, ± 7 -to-20VDC outputs with rated 1500Vrms isolation:

For complete details, contact your nearest sales office or Applications Engineering, 602/746-1111. Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734.



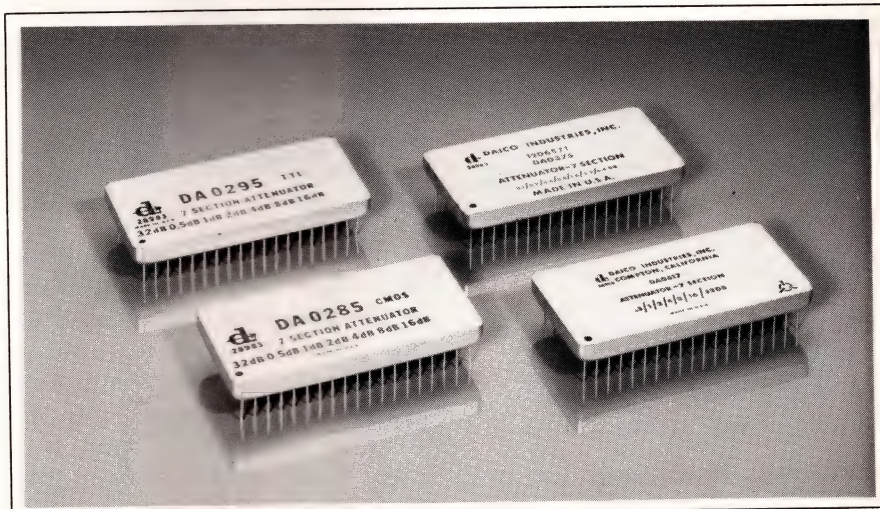
NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

ATTENUATORS

- 30- to 500-MHz operating range
- 63.5-dB attenuation

This 7-bit RF attenuator family features a 63.5-dB attenuation capability in 0.5-dB steps. The devices operate over a 30- to 500-MHz spectrum, have a -55 to $+125^{\circ}\text{C}$ range, and accommodate as much as 13 dBm of input power. Available in both DIP and connectorized versions, the attenuators operate from a 5V supply. The DA0617 provides a 7-nsec transition time, a 25-nsec total switching time, and 50-mV peak transients. The DA0285 and DA0295 low-power alternatives offer CMOS and TTL compatibility, respectively.

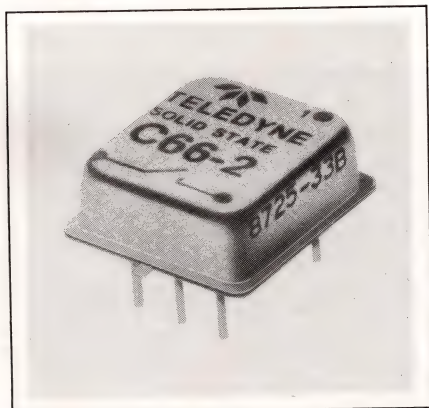


DA0617, \$630; DA0285 and DA0295, \$511 (10).

Daico Industries Inc, 2139 E Del

Amo Blvd, Compton, CA 90220.
Phone (213) 631-1143.

Circle No 365



rating of $\pm 350\text{V}$ at 300 mA. The output leakage current specs at 50 nA max and the on-resistance equals 7.2Ω max. With a 25-mA input current, the turn-off time for both devices equals 300 μsec . C66-1, \$64.35; C66-2, \$65.90 (100). Delivery, stock to eight weeks ARO.

Teledyne Solid State, 12525 Daphne Ave, Hawthorne, CA 90250. Phone (213) 777-0077.

Circle No 366

RELAYS

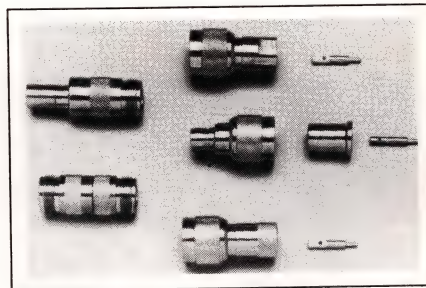
- Designed for ATE applications
- Optically isolated to protect input logic and minimize EMI

Designed to replace electromechanical relays in ATE systems, C66 Series solid-state relays are optically isolated to protect input logic circuitry from output voltage transients, thus minimizing EMI problems. The C66-1 is a power instrumentation relay with an output rating of 800 mA at $\pm 180\text{V}$ continuous. The maximum resistance and leakage current spec at 1Ω and 200 nA, respectively. The C66-2 features a continuous load

CONNECTORS

- Feature 50 Ω line impedance
- Designed for Ethernet systems

This Type N connector, termination, and splice series works with Ethernet systems. Available in coaxial Type N formats, the devices feature twist-on plug connectors for popular RG, Proflex Ethernet PVC, and Teflon-jacketed cables. Typical specifications include a nominal line impedance of 50Ω , a working voltage of 500V rms at sea level, and a VSWR of 1.3 max at 10 GHz. The insulation resistance equals 5000 M Ω and the sea-level dielectric



withstanding voltage is 1500V rms. \$1.80 to \$2.80 (OEM qty).

Cambridge Products Corp, 244 Woodland Ave, Bloomfield, CT 06002. Phone (203) 243-1761.

Circle No 367

MOSFETs

- Available in packaged or die form
- Drain-to-source voltage ratings range as high as 600V

The 23 units in the Power MOS IV line offer usable current ratings as high as 22A, 0.2Ω on-resistance ratings to meet low drive requirements, 800 pF input capacitance, and drain-to-source voltage ratings of 600V max. The input capacitance values range from 2400 to 800 pF,

COMPONENTS & POWER SUPPLIES

and reverse transfer capacitance values are as high as 60 pF. The units are available in TO-3 packages and die form. TO-3 packages, \$4.63 to \$28.86 (100).

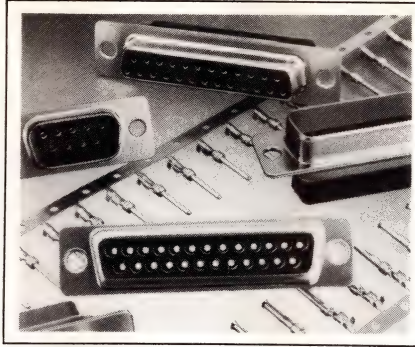
Advanced Power Technology, 405 SW Columbia St, Bend, OR 97702. Phone (800) 222-8278; in OR, (503) 382-8028.

Circle No 368

CONNECTORS

- *Crimp-type contacts reduce installation time*
- *Compatible with all standard D subminiature connectors*

Featuring crimp-insertable contacts, Sigma-D connectors can cut installation time and lower replacement costs. The units are fully compatible with all standard D-subminiature connectors. The connector shell material is steel, zinc-plated with yellow chromate. Tin-plated



shells are also available for applications where shielding is important. The insulators are black, glass-filled nylon, and the brass contact pins and phosphor-bronze sockets have gold over nickel plating. The contacts are available on reels or in loose pieces. 10,000-pin reel, \$240; 25-pin shells, \$0.33 (500). Delivery, stock to six weeks ARO.

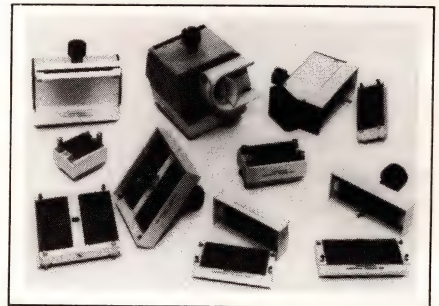
Vernitron Corp, Beau Products Div, Box 10, Laconia, NH 03247. Phone (603) 524-5101. TWX 710-364-1843.

Circle No 369

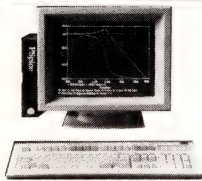
LIF CONNECTORS

- *Feature 700-contact capability*
- *Offer various termination options*

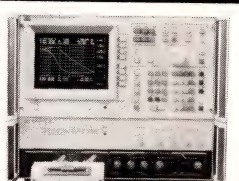
The N Series low-insertion-force (LIF) connectors are available in cable (120 and 700 positions) and rack-and-panel (110 and 350 position) versions. You can specify a model to handle either signal (5A) or power (9A) applications. The signal contacts feature a 0.1×0.1-in. center-to-center grid and are available with a choice of crimp, solder-cup, dip-solder, or wire-wrap termi-



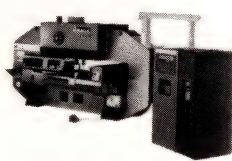
V SERIES SWITCHING POWER SUPPLIES Engineered and Manufactured by Perfectionists!



Simulations by SPICE



Stability by HP/VENABLE



Sheet Metal by AMADA



Auto Insert by UNIVERSAL



Testing by ZEHNTel



Burn in by CENTIGRADE



Service by PHILLIPS

Call Toll Free 1-800-523-2332

Deltron inc.

P.O. BOX 1369 ■ WISSAHICKON AVENUE NORTH WALES, PA 19454
PHONE 215/699-9261 TWX 510/661-8061

CIRCLE NO 21

Cathode Ray Tubes

Thomas Electronics cathode ray tubes ... designed for Military, Commercial and Industrial applications ... from the most sophisticated avionics and photo-recording to the general computer terminal and medical display applications.

Four production facilities to serve you best in Wayne, NJ — Los Angeles, CA — and Clyde, NY.

Send for our new full color catalog, or contact us with your specific requirements.

THOMAS ELECTRONICS

100 Riverview Drive, Wayne, NJ 07470 / 201-696-5200
TELEX: 310-685-3326 / FACSIMILE: 201-696-8298



TE

CIRCLE NO 22

**INTEL'S NEW 80960 FAMILY OF
HIGHLY-INTEGRATED, HIGH-PERFORMANCE
CHIPS, NOW AVAILABLE THROUGH
ALL 58 LOCATIONS**

Imagine microprocessors with an architecture that lets you take high-speed shortcuts to solutions for embedded applications.

Intel did, and they're in stock at Hamilton/Avnet.

Their 32-bit 80960 microprocessors were created with an entirely new architecture, using RISC design techniques and many highly-integrated, on-chip features that give them the best functionality, flexibility and price/performance of any microprocessor for embedded applications.

FUNCTIONALITY: The 80960s are highly-integrated, containing a high-performance FPU, interrupt controller, 512K byte instruction cache, multiple register sets, 32-bit MUXed, burst bus and self test.

FLEXIBILITY: Since so many functions are embedded in the 80960s, they're easy-to-use in a wide range of embedded applications: Systems Controllers such as image processing, robotics and process control; Data Controllers, such as protocol handlers, data formatters and I/O controllers; Event Controllers, such as motor control, engine control and machine and instrument control.

PRICE/PERFORMANCE: They utilize the best of RISC design techniques to provide cost-effective higher performance levels in embedded applications.

Plus, their ability to execute multiple instructions per clock cycle through increased parallelism allows exponential performance growth.

And, because of the high integration of functions, they take up less board real estate and consume less power.

Right now, Hamilton/Avnet can supply you with immediate delivery of 16 and 20 MHz versions, with 7.5 MIPS sustained operation.

Call Hamilton/Avnet today and you can begin building your next embedded application solution with an architecture that can take you everywhere.

For the Hamilton/Avnet location nearest you, call toll free: 1-800-442-6458 (1-800-387-6879 in Canada; 1-800-387-6849 in Ontario and Quebec).

Hamilton Avnet
ELECTRONICS AN AVNET COMPANY

A NEW ARCHITECTURE THAT LEADS TO NEW SOLUTIONS IN EMBEDDED APPLICATIONS:

INTEL 80960 from HAMILTON/AVNET



CIRCLE NO 114

nations. The power contacts are on 0.2×0.2-in. centers and are available with crimp, solder-cup, or 0.47-in. wire-wrap type terminations. \$73 to \$375 (100). Delivery, 14 to 16 weeks ARO.

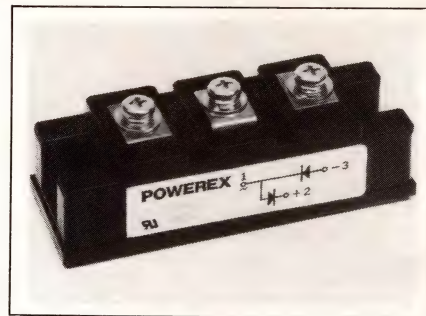
Hypertronics Corp., 16 Brent Dr., Hudson, MA 01749. Phone (617) 568-0451. TLX 951152.

Circle No 370

RECTIFIERS

- Mounted on heat sinks
- Feature 2500V isolation

The CD6 family includes the CD63 dual-SCR module, the CD61 dual-diode module, the CD62 SCR/diode module, and the CS61 single-diode module. All units are available with 800, 1200, 1400, and 1600V blocking



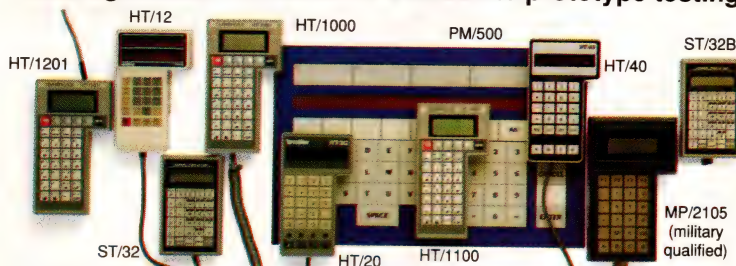
voltage ratings and are isolated to 2500V rms for 1 minute. The CD63 and CD62 devices are rated for continuous current operation at 150 mA, and the diode modules can control 160 mA. The glass-passivated devices are mounted and packaged on electrically isolated copper nickel heat sinks. 160A, 800V dual-diode module, \$44.50 (100).

Powerex Inc., Hillis St., Youngwood, PA 15697. Phone (412) 925-4422.

Circle No 371

Our family.

Catalog models available for immediate prototype testing.



Your features.

We customize or tailor to your requirements.



Choose from a wide variety of handheld and panel mount Termiflex models available for immediate delivery.

It's easy to connect one as the prototype operator interface for the microprocessor-based product you're developing.

As your product evolves, Termiflex becomes part of the development family.

Our engineers work closely with you, helping to specify custom features (from special programming to trademark graphics) that will precisely fit your application and give a strong family resemblance to your product line.

Then we'll build, test, and deliver production quantities to meet your schedule.

And when your control/display unit goes out into the world with your looks and your name, Termiflex will be there if service is ever needed.

Isn't that what families are all about?

Termiflex Corporation
316 Daniel Webster Highway
Merrimack, NH 03054



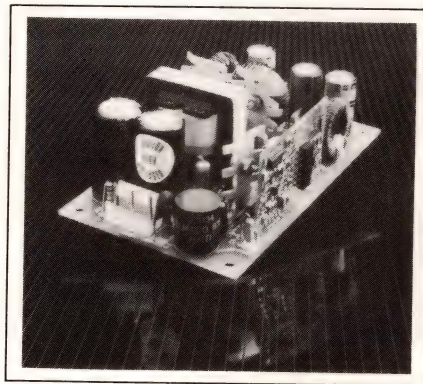
Telephone 603-424-3700
Fax 603-424-0330
Telex 595559

CIRCLE NO 23

POWER SUPPLIES

- Feature a 215,000-hour MTBF
- Designed to meet international safety standards

The SP3-40 Series 40W switching power supplies meet UL, CSA, and VDE safety standards. All three models utilize a single-ended forward converter topology that operates at a 45-kHz switching frequency to achieve a 215,000-hour MTBF. The units supply output combinations of 5V and 12/12V, 24/12V, or 12/5.2V. The minimum specified load on all outputs is 0%. Their efficiency equals 75% min, and short-circuit protection is indefi-



FEATURES

12-Bit Resolution and Accuracy

Fast Conversion Time

AD7672XX03 - 3 μ s

AD7672XX05 - 5 μ s

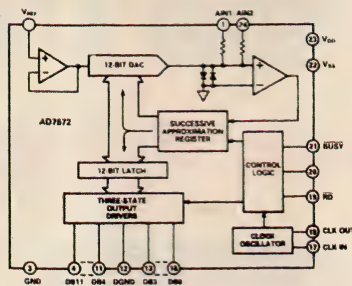
AD7672XX10 - 10 μ s

Unipolar or Bipolar Input Ranges

Low Power: 110mW

Fast Bus Access Times: 90ns

Small, 0.3", 24-Pin Package



AD7672 Functional Block Diagram

PRODUCT DESCRIPTION

The AD7672 is a high-speed 12-bit ADC, fabricated in an advanced, mixed technology, Linear-Compatible CMOS (LC²MOS) process, which combines precision bipolar components with low-power, high-speed CMOS logic. The AD7672 uses an accurate high-speed DAC and comparator in an otherwise conventional successive-approximation loop to achieve conversion times as low as 3 μ s while dissipating only 110mW of power.

To allow maximum flexibility, the AD7672 is designed for use with an external reference voltage. This allows the user to choose a reference whose performance suits the application, or to drive many AD7672s from a single system reference, since the reference input of the AD7672 is buffered and draws little current. For digital signal processing applications, where absolute accuracy and temperature coefficients may be unimportant, a low-cost reference can be used. For maximum precision, the AD7672 can be used with a high-accuracy reference such as the AD588.

The on-chip clock-circuit may be used with a crystal for accurate definition of conversion time. Alternatively, the clock input may be driven from an external source such as a microprocessor clock.

PRODUCT HIGHLIGHTS

1. Fast, 3 μ s, 5 μ s and 10 μ s conversion speeds make the AD7672 ideal for a wide range of applications in telecommunications, sonar and radar signal processing or any high-speed data acquisition system.
2. LC²MOS circuitry gives high precision with low power drain (110mW typ).
3. Choice of 0 to +5V, 0 to +10V or $\pm$ 5V input ranges, accomplished by pin-strapping.
4. Fast, simple, digital interface has a bus access time of 90ns allowing easy connection to most microprocessors.
5. Available in space-saving 24-pin, 0.3" DIP or surface mount package.

AT 5 μ S, WE SET THE 12-BIT A/D RECORD. THIS PAGE TELLS HOW WE BROKE IT.



When we introduced our AD7572, it set the monolithic 12-bit A/D conversion speed record at 5 μ s. Now, our AD7672 establishes a new record with an even faster conversion time of only 3 μ s.

The AD7672 reaches this blazing speed with only 110mW of power dissipation because, like the AD7572, it's manufactured on an advanced merged bipolar/CMOS process.

The 90ns bus access time of the AD7672 affords easy interfacing with most microprocessors, while the +5V and

-12V nominal power supply voltages allow its use in PC and modem designs. All this is available in a narrow 0.3" DIP or a surface mount package, so whatever your application, the AD7672 won't take up much space.

The AD7672 also features unipolar or bipolar analog inputs that are selected by pin-strapping. This lets you avoid external circuitry for input range changing.

For more information on how the AD7672 can speed up your designs, contact the Analog Devices office nearest you.



Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; Headquarters: (617) 329-4700; California: (714) 641-9391, (619) 268-4621, (408) 559-2037; Colorado: (303) 590-9952; Maryland: (301) 992-1994; Ohio: (614) 764-8795; Pennsylvania: (215) 643-7790; Texas: (214) 231-5094; Washington: (206) 251-9550; Austria: (222) 885504; Belgium: (3) 237 1672; Denmark: (2) 845800; France: (1) 4687-34-11; Holland: (1620) 81500; Israel: (052) 28995; Italy: (2) 6883831, (2) 6883832, (2) 6883833; Japan: (3) 263-6826; Sweden: (8) 282740; Switzerland: (22) 31 57 60; United Kingdom: (932) 232222; West Germany: (89) 570050

Grayhill shrinks the I/O module

to save you space, money, and problems

This new series of space-saving I/O modules for control applications measures 0.40" deep and 1.00" high, compared to 0.60" and 1.25" for "standard" models, and reduces the length of a 16-module rack by 4 inches! (The wide side is the same 1.70" as standard modules, for plug compatibility.)

Grayhill mini-modules consume 30% less power than their big brothers, and offer immunity from false triggering caused by electrical transients (per IEEE-472). Using SMT construction, Grayhill shrinks the package, yet upgrades performance even compared to its own standard modules, much less anyone else's. AC output units have lower leakage current, DC output units offer faster switching, and AC input modules have a higher input impedance.

The new mini-modules come in all standard configurations, at pricing comparable to standard-size I/O modules.

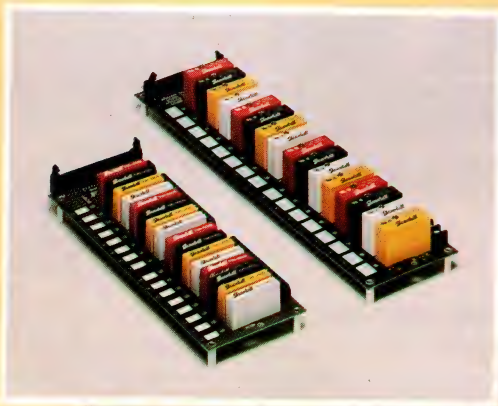


They plug into 16 module racks without screws; a hold-down strip keeps them in place. Surface-mount LEDs with writing space provide status and function indication.

Using the new modules saves you cost at least four ways—you use a smaller rack, a smaller power supply, a smaller

enclosure, and you save the labor of screwing modules into place. And you get better performance besides.

What else could you ask for? How about local availability from Grayhill distributors worldwide! You get that too. So now your next step is send or call for free literature. Do it today.



COMPARISON CHART

PHYSICAL CHARACTERISTICS	STANDARD I/O MODULES	MINI I/O MODULES
Module dimensions	0.60" x 1.70" x 1.25	0.40" x 1.70" x 1.00
16-position rack length	14"	10"
Installation	Individual screw-down	Hold-down strip
ELECTRICAL CHARACTERISTICS		
Power consumption/ module-AC output	18 milliamps	12 milliamps
Pass IEEE-472	No	Yes
Switching speed—DC output	75 μ s turn on 500 μ s turn off	20 μ s turn on 40 μ s turn off
Input impedance—AC input	14K Ohm (120 VAC) 45K Ohm (240 VAC)	22K Ohm (120 VAC) 60K Ohm (240 VAC)

Grayhill
INC.

561 Hillgrove Avenue, P.O. Box 10373
LaGrange, Illinois 60525-0373 USA
Phone: (312) 354-1040 FAX: (312) 354-2820
TLX or TWX: 190254 GRAYHILL LAGE

AVAILABLE LOCALLY THROUGH THESE REPRESENTATIVES

AUSTRALIA/NEW GUINEA Acme Electronics
Kilsyth, Victoria • Tel: (011) (61) (3) 890 0900
BELGIUM/LUXEMBOURG Rodelco SA/NV Electronics
Zaventem • Tel: (011) (32) (2) 720 5013
CHINA, REPUBLIC OF Morrihan International
Taipei • Tel: (02) 752-2200
DENMARK E.V. Johanssen Elektronik A-S
Copenhagen • Tel: (011) (45) (1) 839022
FINLAND OY Flinkenberg & Co., AB
Helsinki • Tel: (011) (358) (0) 647311

FRANCE Radio Television Francaise
Gentilly • Tel: (011) (33) (14) 664-1101
GERMANY Data Modul GmbH
München • Tel: (011) (49) (89) 56 01 70
HONG KONG Components Agent Ltd.
Hong Kong • Tel: (011) (852) (0) 499-2688
INDIA Hindco Corporation
Bombay • Tel: (011) (91) (22) 493-1544
IRELAND, REPUBLIC OF Neltronic Ltd.
Dublin • Tel: (011) (353) (1) 501845

ISRAEL Boran Technologies, Ltd.
Petah Tikva • Tel: (03) 9240925
ITALY Microelit s.r.l.
Milano • Tel: (011) (39) (2) 499 0444
Rome • Tel: (011) (39) (6) 889-4323
JAPAN Japico Corp.
Tokyo • Tel: (011) (81) (3) 348 0611
NETHERLANDS Rodelco BV Electronics
Breda • Tel: (011) (31) (76) 78-4911
NEW ZEALAND S.D. Mandeno
Auckland • Tel: (011) (64) (9) 600-008

NORWAY Hans H. Schive A/S
Asker • Tel: (011) (47) (2) 90 09 00
SINGAPORE, REPUBLIC OF Microtronics Associates Ltd.
Singapore • Tel: (011) (65) 7481835
SOUTH AFRICA, REPUBLIC OF Liberty Electronics (Pty.) Ltd.
Boksburg • Tel: (011) (27) (11) 52 7637
SOUTH KOREA Unistandard Corporation
Seoul • Tel: (82) (2) 532-6815 16
SPAIN Unitronics SA
Madrid • Tel: (011) (34) (1) 242 52 04

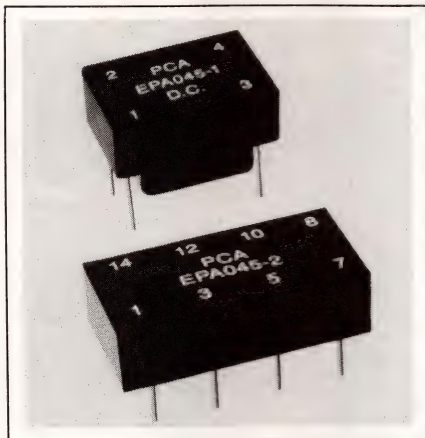
SWEDEN Bo Palmblad Aktiebolag
Bromma • Tel: (011) (46) (8) 252720
SWITZERLAND Walter Blum AG
Zurich • Tel: (01) (41) (1) 312 68 72
UNITED KINGDOM Highland Electronics, Ltd.
Burgess Hill, West Sussex • Tel: (011) (44) (4) 446-4502

COMPONENTS & POWER SUPPLIES

nite. The line and load regulation is 0.1% on the primary output and 0.5% and 3.0% on the auxiliary outputs. With natural convection cooling, the devices' operation is specified over a 0 to 70°C range. \$129. Delivery, stock to eight weeks ARO.

Power General, Box 189, Canton, MA 02021. Phone (617) 828-6216. TWX 710-348-0200.

Circle No 372



EPA045-1, \$1.55 (1000); EPA045-2, \$2.40.

PCA Electronics Inc., 16799 Schoenborn St, Sepulveda, CA 91343. Phone (818) 892-0761.

Circle No 373

ISOLATION MODULES

- Available in 1- and 2-transformer versions
- Pass a 2000V high-potential test

The EPA045 Series Starlan isolation modules are available with one or two transformers (EPA 045-1 and -2, respectively). Designed for hub and node applications, the devices meet the specifications of the IEEE 802.3 standard. To comply with LAN

safety requirements, the transformers pass a 2000V rms high-potential test between the primary and secondary windings (coil-to-coil in the -2 version). The transformers have a 1:1 ($\pm 5\%$) turns ratio and a maximum dc resistance (both primary and secondary) of 1 Ω . Maximum primary-to-secondary leakage inductance and interwinding capacitance are 8 μ H and 25 pF, respectively. Rise time is 100 nsec max.

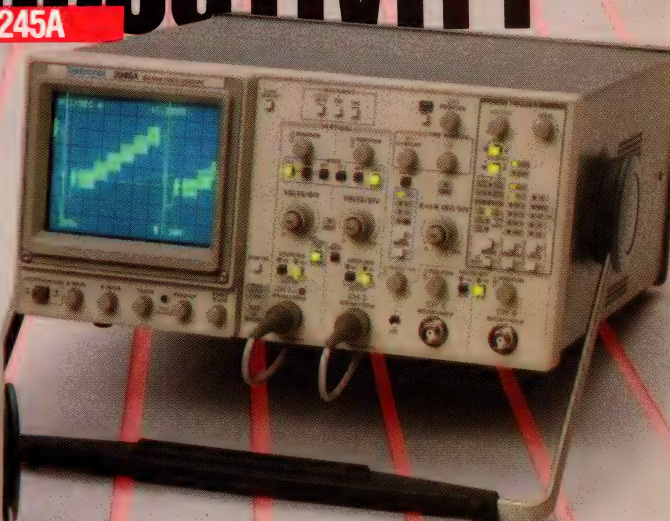
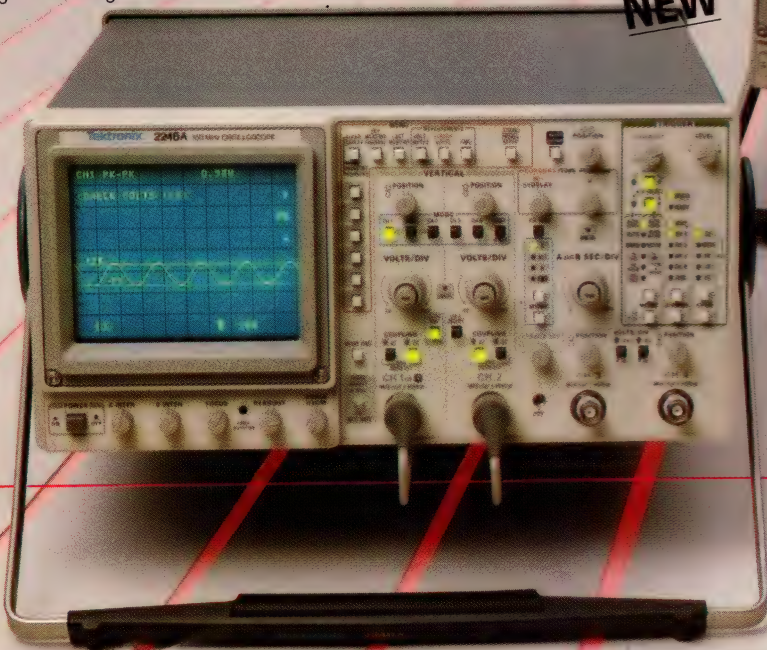
Featuring an integrated power supply, the VXA Series pulse-width-modulated amplifiers provide incremental and continuous motion control for dc servos requiring as much as 384W (768W peak). These compact 8.7 $\times$ 2.9 $\times$ 7-in., 4-quadrant amplifiers can operate in velocity and torque modes. The devices' adjustable compensation simplifies servo system stabilization. Operating on 12 to 36V ac or 14 to 50V dc,

PACESETTER PRODUCTIVITY

100 MHz TEK 2246A/2245A

Smart scopes, perfect setup! Tek sets the new, fast pace for frequent measurements with automatic front panel setup. Nonvolatile memory for up to 20 front-panel setups (2246A). Time and voltage cursors. Exclusive SmartCursors™ track waveform changes for voltage measurements. All backed by Tek's 3-year warranty.

NEW



Call Tek direct
for PaceSetter specs!
1-800-426-2200

Prices subject to change without notice.

Copyright ©1988, Tektronix, Inc. All rights reserved. TTA 906-A

Tektronix
COMMITTED TO EXCELLENCE
CIRCLE NO 24

WHEN RELIABILITY IS IMPERATIVE.®



ABBOTT'S NEW M25; A HIGHER PERFORMANCE, 25-WATT SWITCHING POWER SUPPLY

Abbott's new M25 exceeds the performance of one of the best selling mil-spec power supplies; our own VN25. Our VN25 has been widely used in critical naval and airborne applications for over 10 years. Now the M25 offers higher performance in this proven design.

Higher Density. The M25 has a 1 1/4 inch lower profile than our VN25 while maintaining the same footprint. This adds up to a **45% reduction** in volume.

Better Specs. By doubling the switching frequency, our M25 is 10% more efficient, while at the same time providing a **23% wider** operating temperature range.

Greater Reliability. By using innovative design techniques, the M25 achieves a **4-fold increase** in MTBF.

EMI Compliance. All M25 standard units meet MIL-STD-461B for emissions and susceptibility.

The M25 is encapsulated and hermetically sealed, and meets the stringent environmental requirements of MIL-STD-810C and MIL-S-901C.

Abbott's new M25: higher performance in a proven design.

Call or send for specs and our full line catalog.

Abbott Transistor Laboratories, Inc. Power Supply Division,
2727 La Cienega Blvd., Los Angeles, CA 90034 (213) 936-8185. Eastern
Office: (201) 461-4411, Southwest Office: (214) 437-0697, London Office:
0737-82-3273.



MODEL M25 SPECIFICATIONS

DIMENSIONS	
Input frequency	6.25" x 2.75" x 1.5"
Input voltage	47-440 Hz
Outputs	103.5 to 126.5 V rms
Efficiency	5, 12, 15, 24, 28 V
Ripple/noise	70% minimum
Line regulation	20 mV rms/100 mV p-p
Load regulation	10 mV
EMI	25 mV
Environment	MIL-STD-461B
	MIL-STD-810C
	MIL-S-901C
Input protection	MIL-STD-1399 sec 103
Operating temperature range	-20°C to 71°C
Storage temperature range	-55°C to 85°C
MTBF* (ground benign)	
Standard	176,000 hours
ER Option	759,000 hours
MTBF* (naval sheltered)	
Standard	33,000 hours
ER Option	125,000 hours
*MIL-STD-217D (50°C baseplate)	

abbott

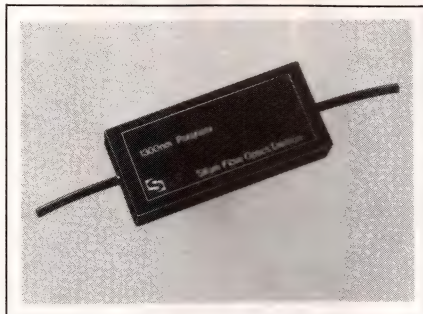
MILITARY POWER SUPPLIES

COMPONENTS & POWER SUPPLIES

the amplifiers have a 1.01 form factor. \$349. Delivery, six to eight weeks ARO.

PMI Motion Technologies, 49 Mall Dr, Commack, NY 11725. Phone (516) 864-1000. TLX 510-223-0007.

Circle No 374



FIBER POLARIZER

- Has an extinction ratio in excess of 40 dB
- Suitable for use with fiber-optic telecom links

This single-mode fiber-optic polarizer provides an extinction ratio of >40 dB, and an insertion loss for transmitted light of <0.5 dB. It works by coupling light in the unwanted polarization state into a plasma wave that's supported on a thin film deposited on the fiber. The polarizer has an operating temperature range of -40 to +85°C; the

extinction ratio varies by ± 2 dB. Versions are currently available with operating wavelengths of 1300 and 1550 nm. The polarizer is housed in a 45×20×10-mm package with 1m fiber pigtailed. The company can adapt the technique for use with all types of single-mode optical fibers, including low and high birefringence types. Approximately £800 (10).

Sifam Ltd, Fibre Optics Division, Woodland Rd, Torquay, Devon TQ2 7AY, UK. Phone (0803) 63822. TLX 42864.

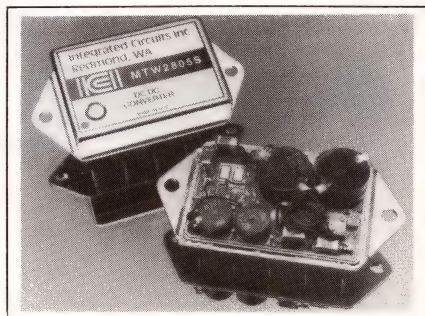
Circle No 375

DC/DC CONVERTERS

- Has 30W outputs
- 300-kHz typ switching frequency

The MTW Series of 30W dc/dc converters includes four models, whose individual outputs are 12V at 2.5A, 15V at 2A, ± 12 V at ± 1.25 A, and ± 15 V at ± 1 A. All models accept inputs from 18 to 40V. Housed in a 1.95×1.35×0.5-in. package, the converters have a power density of 22.8 W/in. Switching frequencies range from 240 to 300 kHz, and the converters' efficiency rate is 84% to

Text continued on pg 243

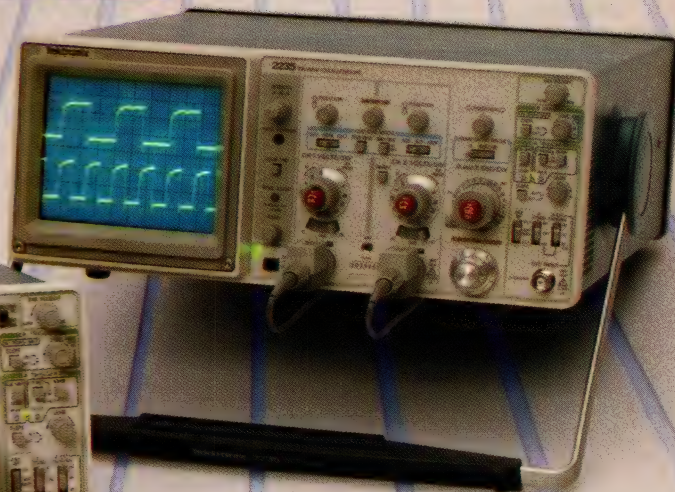


PACESETTER PERFORMANCE

100 MHz TEK 2236/2235

100 MHz scope, counter, timer, DMM—just \$2795

The ultra-versatile Tek 2236 makes measuring everything from frequency, period and width to delay time and Δ time push-button easy—in addition to CRT display, you get digital readout display accurate to 0.001% and beyond. PaceSetter performance on a modest budget? Look at the 100 MHz, dual-trace Tek 2235 with the best of the basics—just \$1575!



Call Tek direct
for PaceSetter specs!
1-800-426-2200

Prices subject to change without notice.
Copyright ©1988, Tektronix, Inc. All rights reserved. TTA 906-B

Tektronix
COMMITTED TO EXCELLENCE
CIRCLE NO 25

Experience Counts.



EZ-PRO Emulators

Experience quick delivery, easy operation, fast development schedules. EZ-PRO® users reap the benefits of the C language fully integrated with advanced emulation tools, including precedence triggering, Deep Trace™, on-line code revisions, and performance analysis tools.

In addition to IBM® PC-XT/AT, hosts include IBM Personal

System/2™, Macintosh II™, VAX™, MicroVAX™, and Sun Workstation®.

EZ-PRO users also have the advantage of the best post-sales support in the industry.

They know that their emulators are covered by

American Automation's 5-year limited warranty.

Experience counts. Now with over 10 years experience, American Automation has designed more emulators than anyone. Count on EZ-PRO to provide the most cost/effective development support.

Intel: 8031 8032 8086 8035 8088 8039 80186 8344 80188 8048 80286 8049 8050 8051 8085A 8085A2 8096/97	Motorola: 6800 68B00 68HC11A2 68HC11A8 6802 68B02 146805E2 6803 6808 68B08 6809 6809E 68B09 68B09E	Hitachi: 6301R 6301V1 6301X 6301Y 6303R 6305V 63705 6309 6309E 64180R0 64180R1	Rockwell: 6502 6503 6504 6505 6506 6507 6512 6513 6514 6515	RCA: 1802 1805 1806 CDP6805C4 CDP6805C8 CDP6805D2 CDP6805E3	Zilog: Z80A Z80B Z80H Z180 Z8001 Z8002
				Harris: 80C86 80C88	NEC: V20 V40 V30 V50
				National: NSC800	Signetics: 8X300 8X305

...AND MORE

*Assumes EZ-PRO Development Station connected to MSDOS host.

american automation 

2651 Dow Avenue, Tustin, California 92680 (714) 731-1661

FAX: 714/731-6344

CIRCLE NO 118

IBM is a registered trademark of International Business Machines, VAX and MicroVAX are registered trademarks of Digital Equipment Corporation, Macintosh is a registered trademark of Apple Computer, Inc., Sun Workstation is a registered trademark of Sun Microsystems, Inc.

COMPONENTS & POWER SUPPLIES

86%. Additional features include short-circuit protection, input and output filtering, and an inhibit-function input. Environmental screening to MIL-STD-883 is available as an option. Single and dual output models, \$453 and \$487 (100), respectively. Delivery, stock to 8 weeks.

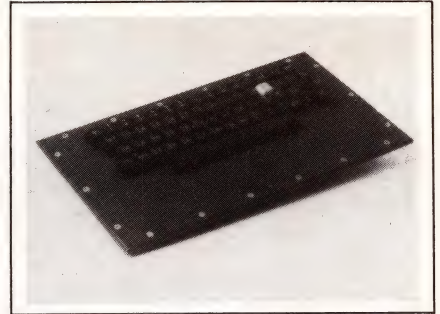
Integrated Circuits Inc., Box 97005, Redmond, WA 98052. Phone (800) 822-8782. TWX 910-443-2302.

Circle No 376

unit offers 1.23 W-hrs of energy per in³. The device delivers as much as 40A of high-rate discharge current. Battery lifetime is at 5 years min. You can recharge it between 200 to 500 times, depending on the average depth of discharge. \$16 (500).

Power-Sonic Corp., Box 5242, Redwood City, CA 94063. Phone (415) 364-5001. TLX 348400.

Circle No 377



5-YEAR BATTERY

- Offers 1.23 Whrs of energy per in³
- 5-year (min) lifetime

The Model PS-1242 is a 12V, sealed lead-acid battery. It's maintenance free, rechargeable, usable in any position, and suitable for both standby and deep-cycle applications. With a 4-Ahr capacity and a 3.54×2.75×4.01-in. package, the

KEYBOARD

- Meets MIL-STD-810C
- Keyswitches have 20 million actuation lifetime

The 30498-05, a standard Type 1/Class 1 Qwerty full-travel military keyboard, features 59 metal-housed keyswitches that are mounted on a metal base. It meets the requirements of MIL-STD-810C as well as specifications for EMI/RFI and Tempest. Its keycaps are 0.5 in.

square and are mounted on 0.75-in. centers. They are black with gray legends that are pad printed according to MIL-M-18012. The keyswitches utilize conductive rubber technology and are rated for 20 million actuations. The keyboard comes with an X-Y matrix for a standard output; optional serial and parallel interfaces are available. \$1095 (100). Delivery, eight to 10 weeks ARO.

IEE Inc., 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 378

PACESETTER PRICE

50 MHz TEK 2210/2225

Best-of-class performance at

\$995/\$2195

Get the PaceSetter start in digital storage with Tek's NEW 50 MHz 2210. Featuring 20 MS/s per channel digitizing, 4K record length per channel plus familiar, full-bandwidth analog operation for just \$2195. And for pure and simple analog performance with unmatched economy, look at the popular, 2-channel Tek 2225—just \$995!

NEW 2210
20 MS/s per channel



Call Tek direct
for PaceSetter specs!
1-800-426-2200

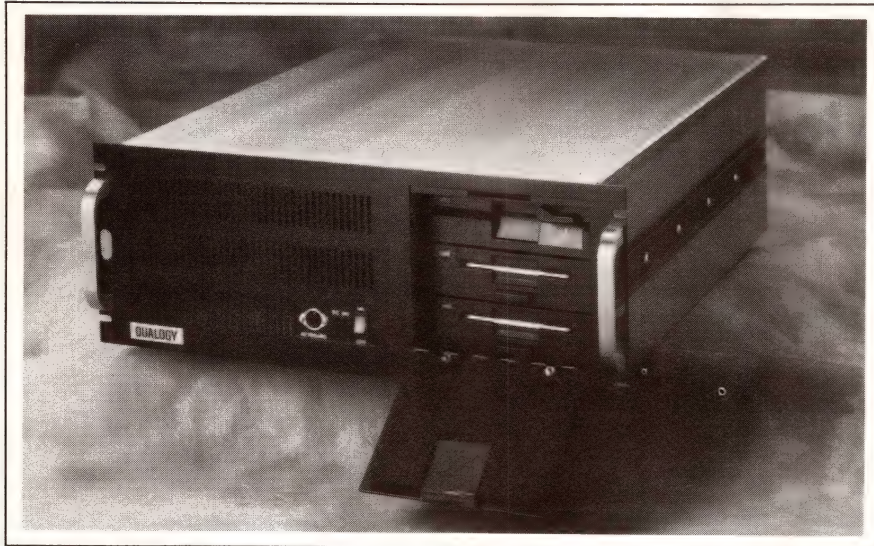
Prices subject to change without notice.
Copyright ©1988, Tektronix, Inc. All rights reserved. TTA 906-C

CIRCLE NO 26

Tektronix
COMMITTED TO EXCELLENCE

NEW PRODUCTS

COMPUTERS & PERIPHERALS



RACK-MOUNT PC/AT

- Features an 80286 μ P and 1M byte of RAM memory
- System meets EIA standards for installation in 19-in. rack

The QPC-7000 IBM PC/AT-compatible computer meets EIA standards for mounting in a standard 19-in. rack. A single-board computer (SBC), the QPC-521, occupies one slot of a 12-slot passive backplane. The SBC features an 80286 μ P operating at 10 MHz, 1M byte of RAM, a socket for an 80287 coprocessor, a

floppy-disk controller, a SCSI Winchester-disk controller, a serial port, a parallel port, and a clock/calendar with battery backup. The remaining 11 slots are available for the user. The system has a 200W power supply and a carrier assembly capable of handling three half-height drives. The unit measures 19 $\times$ 24 $\times$ 8.75 in. \$2790.

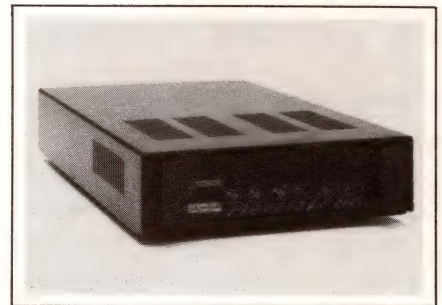
Qualogy Inc., 2241 Lundy Ave, San Jose, CA 95131. Phone (408) 434-5200. TLX 4993489.

Circle No 380

panded to 500M bytes. A configuration with a 21-in. monochrome monitor, 4M bytes of memory, three 80M-byte disks, and development software costs \$26,795.

Texas Instruments Inc., Data Systems Group, Box 181153 DSG-179, Austin, TX 78718. Phone (800) 527-3500.

Circle No 381



MODEM CARDS

- 14.4k-bps full-duplex operation over 4-wire leased lines
- Boards conform to CCITT V.33 and V.29 recommendations

The AJ 1441-1 and AJ 1441-1D 14.4k-bps modem cards for the company's modular modem system provide synchronous, full-duplex operation over 4-wire unconditioned leased lines with Trellis-coded modulation. They both meet the CCITT V.33 recommendation at 14.4k and 12k bps, and CCITT V.29 at 9600, 7200, and 4800 bps. The diagnostic features include a numeric display indicating signal quality and the ability to read the received signal quality of individual remote modems. An eye pattern generator is available as an option. The AJ 1441-1D provides disaster recovery via its unattended dial backup feature. AJ 1441-1, \$2045; in a case, \$2295; AJ 1441-1D, \$2345; in a case, \$2595.

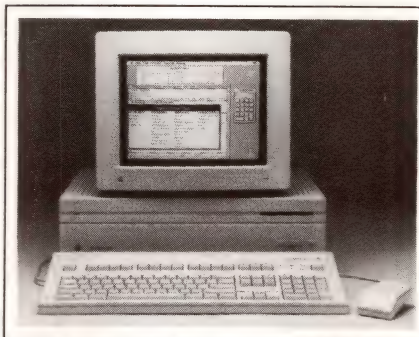
Anderson Jacobson Corp., 521 Charcot Ave, San Jose, CA 95131. Phone (408) 435-8520.

Circle No 382

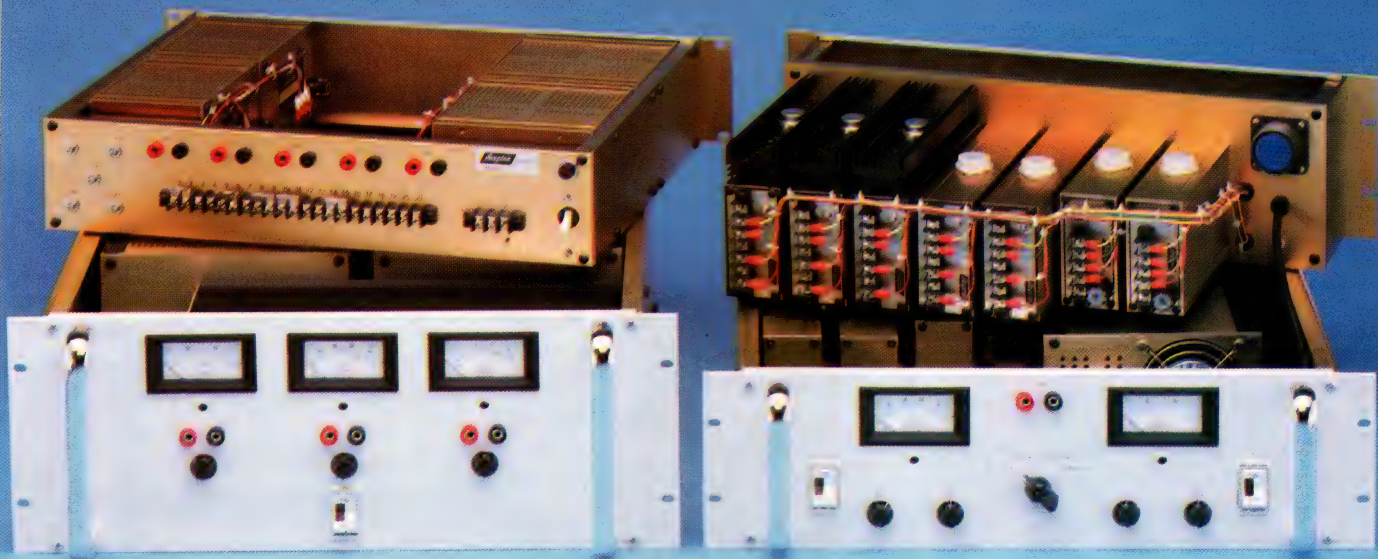
AI WORKSTATION

- Macintosh II PC equipped with a TI Explorer Lisp board
- Board runs Lisp software and accesses MAC II software

The microExplorer AI workstation, built in a Macintosh II personal computer, incorporates a coprocessor board that utilizes the Explorer Lisp μ P. The board can address as many as 12M bytes of memory and occupies a single NuBus slot. All systems come with a run-time version of the Explorer software that reduces memory and mass-storage requirements. The software provides symbolic processing power, as



well as access to the large base of systems and applications software available for the MAC II. Explorer and Macintosh operating environments execute concurrently. The system includes a math coprocessor, and disk-storage space can be ex-



How to Get Your Multiple-Output Power System Shipped in Only 9 Days

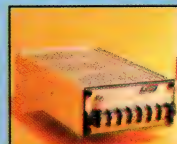
Call the toll-free number below and ask for our Power Systems Department. Specify the voltages and currents you require. Also, tell us the operating features and accessories you need, such as voltmeters, ammeters, front panel controls, handles and chassis slides.

We'll promptly call you back with a detailed description, firm price and a special model number to use when ordering. Then, in only nine days after we receive your order, we'll ship your power system to you...completely assembled, wired and tested.

If you prefer to select the complement of power supplies for your system, call us and **ASK FOR OUR 52-PAGE CATALOG**. It includes specs, drawings and prices for our full line of single, dual and triple output power supplies.



P.O. Box 638, Easton, PA 18044
Call toll-free (800) 523-9478
In Pennsylvania, call (215) 258-5441



Acopian ships power modules in 3 days, systems in 9 days.



IMAGE DISPLAY

- Updates images every 0.2 sec with 256 shades of gray
- 2048×1536 viewable pixels

The GMA 251 digital image display with an ultra-high-resolution 19-in. monochrome monitor provides a screen resolution of 2048×1536 viewable pixels. It can store 2048×2048 pixels and its scroll feature can access and display the entire image stored in memory. Incorporating a high-speed frame buffer, a D/A converter, and a display in one self-contained unit, the system achieves updates of images with 256 shades of gray every 0.2 sec. Astigmatism correction and dynamic focusing enhance the screen's resolution by providing image focusing in the corners as well as in the center of the screen. An optional WB (P45) phosphor with a high-contrast filter is available for high-contrast viewing. \$16,250. Delivery, 12 weeks ARO.

Tektronix Inc., Display Devices Div, Box 500, Beaverton, OR 97077. Phone (800) 835-9433.

Circle No 383

PRINTER ADAPTER

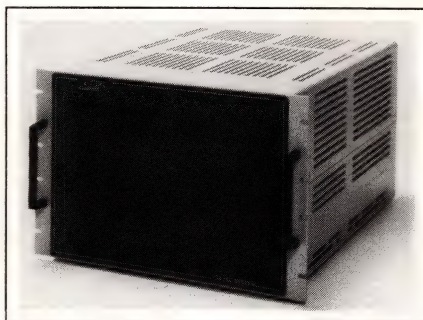
- HP's LaserJet Series II for IBM's System/36 and 38
- Card appears plug-compatible with an IBM 5219 printer

The I-O 8200HP LaserCard adapter plugs into the optional I/O slot at the rear of an HP LaserJet Series II printer. To an IBM System/36 or a System/38 computer, the card appears plug-compatible with an IBM

5219 printer and provides many of the features of IBM's 3812 printer. You can gain access to HP LaserJet fonts by specifying an IBM Type-Style number in a DisplayWrite/36 word processor. The word processor supports A, B, D, E, G, H, L, M, N, Q, and R cartridges. An Auto DP mode provides automatic page orientation and font selection for printing 80, 132, and 198 column data. \$995.

I-O Corp., 2256 S 3600 W, Salt Lake City, UT 84119. Phone (801) 973-6767. TLX 383783.

Circle No 384



VXI BUS SYSTEM

- Instruments and test functions on a card
- Comes with an IEEE-488-to-VXI Bus interface

The Model 73A-PRT prototyping system is based on the VXI Bus standard. VXI stands for VME eXtensions for Instrumentation, and you can use the system in automatic testing areas. The unit contains an IEEE-488-to-VXI Bus interface located on the 73A-151 card and two wire-wrap cards for developing prototype instruments. The 73A-151 contains the VXI Bus slot-0 functions and hardware/software to communicate with an adapter card. The adapter card lets you connect to more than 60 of the company's field-tested instruments. The system serves as a resource manager that oversees power-up self-test, module address allocation, and definition of system hierarchy. Each of the system's 13 card slots accommodates a VXI module that dissipates as much

More quality switching components from P&B

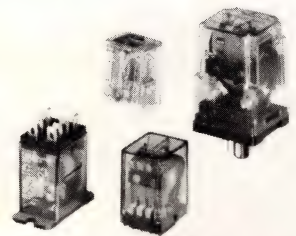
Time Delay Relays



P&B time delay relays combine precision, solid state timing circuits with our proven electromechanical relays. A wide selection of timing functions, timing ranges, degrees of precision and package styles permits you to select a unit with just the features you need.

CIRCLE NO 42

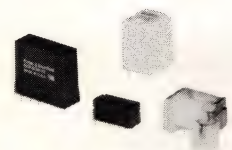
General Purpose Relays



One of the broadest lines of general purpose relays in the industry is available from P&B. Open and enclosed styles are offered with various contact arrangements, contact materials, termination styles and coil voltages.

CIRCLE NO 43

P.C. Board Relays



For loads from dry circuit through 30 amps, P&B P.C. board relays provide the features you need. Open, enclosed and sealed relays meet requirements established by international regulatory agencies.

CIRCLE NO 44

P&B circuit breakers provide the quality you need at a price you can afford.

Quality and selection

Depend on P&B circuit breakers for the highest standards of quality at an affordable price. Both thermal and magnetic/hydraulic types are offered in a variety of models. Many are UL recognized as supplementary protectors and CSA certified as appliance component protectors.

Value enhanced designs

We constantly evaluate, upgrade and expand our broad line of circuit breakers to meet your needs. Our W28 fuse replacement, thermal models give you the confidence of established designs and the pricing of current, automated technology. Both standard size and Mini-Mag series magnetic/hydraulic circuit breakers recently have been expanded to provide a broader range of circuit functions.

Service and application assistance

Should you need assistance in specifying or applying P&B circuit breakers, our sales force of more than 400 sales representatives is well-trained and ready to serve you. P&B circuit breakers are available off-the-shelf from our nationwide network of authorized distributors.

Specify P&B circuit breakers with the utmost confidence

Contact us today to find out more about P&B circuit breakers. Potter & Brumfield, A Siemens Company, 200 South Richland Creek Drive, Princeton, Indiana 47671-0001.

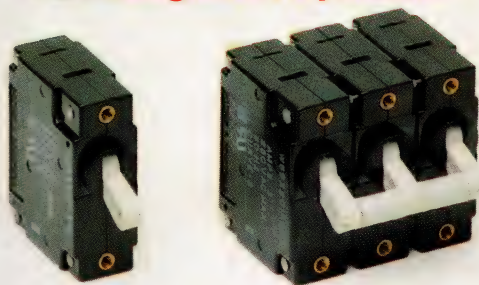
Call toll-free 1-800-255-2550 for the P&B authorized distributor, sales representative or regional sales office serving your area.

Potter & Brumfield

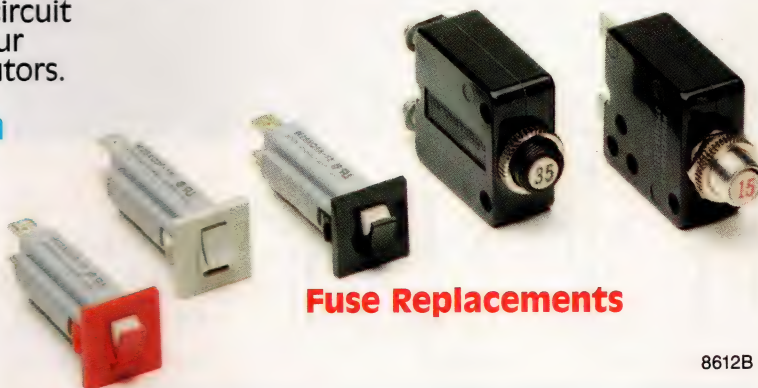
CIRCLE NO 27



Magnetic/Hydraulic



Thermal



Fuse Replacements

8612B

Select the type that's right for your application.

Magnetic/Hydraulic

Mini-Mag breakers available in ratings from 0.25 through 30 amps, single to four pole designs. Standard size breakers; 0.25 through 50 amps, up through six poles. Broad range of trip curves and circuit functions, including dual coil models. Priced for volume applications in computers and office machines.

Thermal

Single pole push-to-reset, push/pull and toggle styles. Ratings from 0.25 through 60 amps. Variety of mounting and termination options. Consistent quality through automated manufacture.

Fuse Replacements

Functional replacements for fuse applications add value to your product. These inexpensive thermal units are ideal for power strip, appliance, marine and office machine applications. Approved by many international agencies.

SHARP FLAT PANEL DISPLAYS



Thin is In.

As any designer will attest, the latest rage in the electronics industry are liquid crystal and electro-luminescent flat panel displays. The reason for their popularity is clear — thin displays mean sleeker, more efficient designs.

Sharp is the recognized leader in LCD and EL flat panel displays.

With over 30 years experience in building the world's clearest, most reliable displays,

Sharp is sure to make an LCD to fit your needs.

Of course, the most popular place to order your Sharp displays is Marshall Industries. In fact, Marshall is the only national distributor of Sharp LCDs. But that's the kind of privilege you expect when you have over 30

years experience serving the electronics industry.

When you need a clear display that fits just right, remember the leader in flat panel displays. Sharp. And remember the best place to find them. Marshall.

Because Marshall knows you can never be too sharp or too thin.

Marshall

(*Authorized Locations)

AL Huntsville (205) 881-9235*
AZ Phoenix (602) 496-0290*
 Tucson (602) 790-5687*
CA Irvine (714) 859-5050*
 Los Angeles (818) 407-4100*
 Sacramento (916) 635-9700*
 San Diego (619) 578-9600*

San Francisco (408) 942-4600*
CO Denver (303) 451-8383*
CT Connecticut (203) 265-3822*
FL Ft. Lauderdale (305) 977-4880*
 Orlando (305) 767-8585*
 Tampa (813) 576-1399*
GA Atlanta (404) 923-5750*

IL Chicago (312) 490-0155*
IN Indianapolis (317) 297-0483*
KS Kansas City (913) 492-3121*
 Wichita (316) 264-6333*
MA Boston (617) 658-0810*
MD Maryland (301) 840-9450*
MI Michigan (313) 525-5850*

MN Minneapolis (612) 559-2211*
MO St. Louis (314) 291-4650*
NC Raleigh (919) 878-9882*
NJ N. New Jersey (201) 882-0320*
 Philadelphia (609) 234-9100*
NY Binghamton (607) 798-1611*
 Long Island (516) 273-2424*

Rochester (716) 235-7620*
OH Cleveland (216) 248-1788*
 Dayton (513) 898-4480*
 Westerville (614) 891-7580*
OR Portland (503) 644-5050*
PA Pittsburgh (412) 963-0441*
TX Austin (512) 837-1991*

Brownsville (512) 542-4589*
 Dallas (214) 770-0616*
 El Paso (915) 593-0706*
 Houston (713) 895-9200*
 San Antonio (512) 734-5100*
UT Salt Lake City (801) 485-1555*
WA Seattle (206) 747-9100*
WI Wisconsin (414) 797-8400*

as 35W. \$7490.

Colorado Data Systems Inc.,
3301 W Hampden Rd, Unit C, Englewood, CO 80110. Phone (303) 762-1640.

Circle No 385

Bicc-Vero Electronics Ltd, Flanners Rd, Hedge End, Southampton SO3 3LG, UK. Phone (0703) 266300. TLX 477984.

Circle No 386

Bicc-Vero Electronics Inc., 1000 Sherman Ave, Hamden, CT 06514. Phone (203) 288-8001. TWX 510-227-8890.

Circle No 387

ETHERNET ADAPTER

- Provides 10M-byte/sec rate for the Macintosh II
- The IEEE-802.3-compatible board occupies one NuBus slot

The EtherLink/NB Ethernet adapter for the Macintosh II operates with the company's 3+ or Apple's AppleShare network operating sys-



PROTOTYPING CARD

- Includes Multibus II iPSB bus interface logic
- Terminals accept DIP, SIP, PGA, and discrete components

This Multibus II prototyping card provides interface circuitry for the Multibus II iPSB bus already tracked onto the board. It comes complete with bus drivers, an 8751H microcontroller to control the Multibus II interconnect space, and a socket for an Intel message-passing coprocessor. The interface logic occupies 30% of the 233.3x220-mm board area. More than 260 cm² of this area contains either wire-wrap or Speedwire terminals on a 0.1-in. pitch for DIP, SIP, and discrete components, and 80 cm² of 0.1-in. matrix terminals suitable for pin-grid-array devices. The 8-layer board includes three independent power-supply planes, a ground plane, and surface-mount decoupling capacitors. The interface logic allows you to isolate the board from the iPSB bus for test purposes. Documentation for circuit and microcontroller firmware comes with the package. £850.



||: ||

**Faced with rad-hard semi-custom requirements?
Flexibility and performance are waiting at the
other end of the line.**

Marconi's MACROSOS Design System employs a silicon-on-sapphire and self-aligning silicon gate process to achieve significant improvements in speed, higher packing densities and much greater radiation tolerance.

If you'd like to learn how this macrocell design style can offer almost unlimited functionality and a low-risk route to complex or mixed analogue and digital systems, call a Marconi Sales Engineer today at 516-231-7710. We're waiting to assist you.

☐ Please send complete information on Marconi's MACROSOS Design System

Name

Company

Address

City State Zip

Phone

Marconi

EDN51288

Electronic Devices, Inc. • 45 Davids Drive, Hauppauge, NY 11788

READY

OUR NEW 1600 WATT, MULTI OUTPUT POWER SUPPLY IS READY...

READY TO SOLVE YOUR MOST DEMANDING HIGH POWER REQUIREMENTS

You can have a main output of 5V @ 200A Plus four more outputs, up to 600 watts, in one small package.

Check the chart below.

READY FOR YOUR TOUGHEST SIZE REQUIREMENTS

acdc electronics put 1600W in a 5" x 8" x 13" package. That makes it, the JFM Series the SMALLEST 1600W multi output power supply available. Anywhere.

READY FOR DELIVERY

Don't wait for the power supply you need.

You can have the output voltage combination you choose* in two weeks.

*From the model selection chart.

READY WITH UNBEATABLE SPECIFICATIONS

- ☐ Current monitor
- ☐ Independent output inhibit, margining, monitoring
- ☐ Internal EMI filter meets FCC & VDE Class A
- ☐ No minimum load required on any output
- ☐ Floating outputs
- ☐ Single-wire paralleling
- ☐ 30 Ms holdover storage

WAIT

Wait until you see this power supply. Wait until you test it.

If you have a requirement for reliable high power with flexibility in output voltages—don't wait.

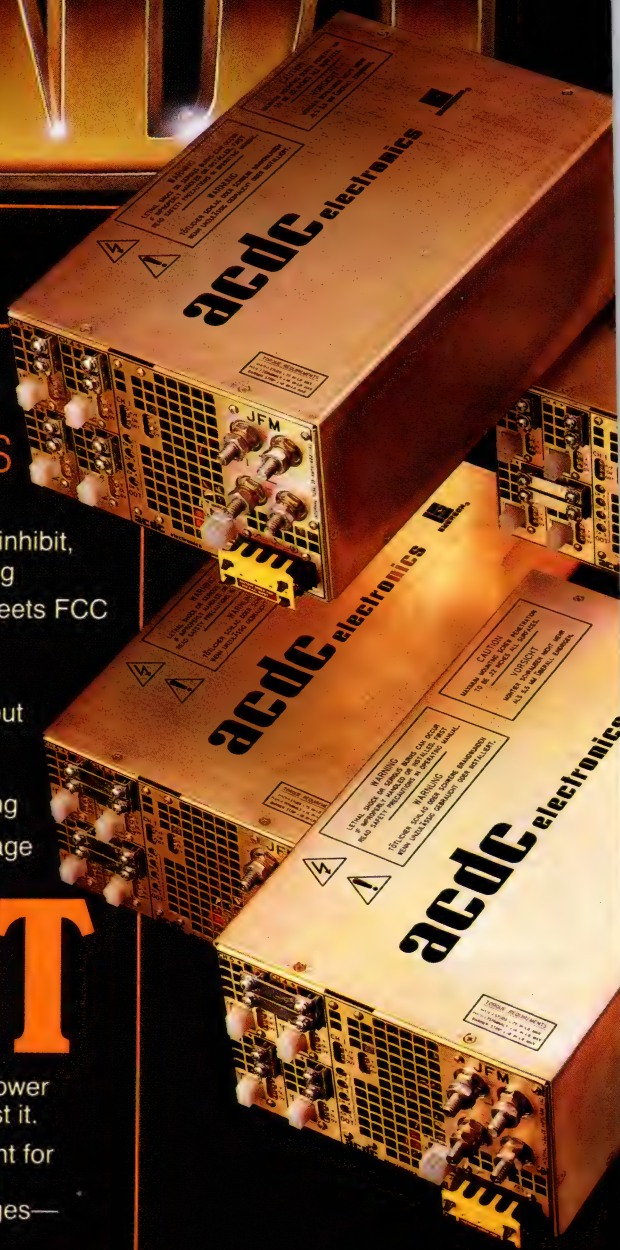
Call for an immediate demo. 619/439-4200.

1600W MULTI	CH2	CH3	CH4	CH5
MAIN OUT				
5V/200A	TABLE A or B	TABLE A or B		
5V/200A	TABLE A or B	TABLE B	TABLE A or B	
5V/200A	TABLE B	TABLE B	TABLE B	TABLE B
1500w	800w	500w	300w	
1600w	1000w	750w	400w	220w

TABLE A AUX's	TABLE B AUX's
5V/60A	5V/30A
12V/30A	12V/15A
15V/24A	15V/12A
24V/15A	24V/7.5A
175w	70w
135w	15w
	40w

ACDC's POWER OFFERING

CIRCLE NO 138



acdc electronics

401 Jones Road, Oceanside, CA 92054.
TEL: 619/757-1880. TLX: 350227. FAX: 619/439-4243

tems. It can interface with a 10Mbps Ethernet network, using coaxial or twisted-pair wiring. An onboard transceiver drives twice the length of the IEEE-802.3 specification, which measures 1000 ft. The bus interface provides 32-bit data transfers for high-speed network operation. According to the vendor, the use of VLSI components improves reliability and reduces power consumption. A 32k-byte ROM provides automatic hardware identification and configuration of parameters to simplify installation and use. A 16k-byte packet buffer permits reception of back-to-back packets, reducing network traffic. The board's design is based on the National Ethernet chip set. \$595.

3Com Corp, 3165 Kifer Rd, Santa Clara, CA 95052. Phone (408) 562-6400.

Circle No 388



COMPUTER BOARD

- *Runs a 68030 μ P and a floating-point coprocessor*
- *Accepts daughter boards to increase its functionality*

The JT-68030SBC CPU card for VME Bus systems accepts a variety of daughter boards that increase its functionality. It runs a 68030 μ P and an optional 68881 or 68882 floating-point coprocessor. The board also provides 1M or 4M bytes of dual-port, parity-checked RAM, space for as much as 2M bytes of EPROM, and two serial I/O lines. The daughter boards interface to the CPU card via a local 68020-style bus. Available daughter boards in-

clude memory expansion, SCSI interface, and prototyping modules. The JT-Duram daughter board provides an additional 1M, 2M, 4M, or 8M bytes of RAM, and either 6 or 8 RS-232C I/O ports. You can add two JT-Duram boards to the CPU card. The JT-SCSI daughter board is an intelligent disk and tape controller card. Its onboard 68020 μ P provides

DMA that can transfer data to and from as many as seven SCSI devices at data rates as high as 4M bytes/sec. The JT-Proto daughter board, which accepts Speedwire terminals on a 0.1-in. pitch, allows you to construct your own add-on boards. You can plug as many as three daughter boards into the CPU card to produce an assembly that still fits



**Marconi is really moving with the fastest
16 x 16 MAC available.**

We've combined low power consumption and the intrinsic rad-hardness of our CMOS/SOS with real-time image processing, real-time radar processing, computer graphics and digital communications.

Investigate our large family of Digital Signal Processors. Call A Marconi sales engineer today at 516-231-7710.

You'll see why we're in the fast lane.

- ☐ Please send details on Marconi's 16 x 16 MAC
- ☐ Please send information on Marconi's entire family of DSP devices

Name _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone _____

EDN51288

Marconi

Electronic Devices, Inc. • 45 Davids Drive, Hauppauge, NY 11788

into two VME Bus slot widths. These assemblies are suitable for running Uniplus+ V2.2 or OS-9 operating systems. The prices for the following models are approximate: JT-68030SBC, £3500; JT-Duram from £1000 to £4700; JT-SCSI, £660; JT-Proto, £250 (100).

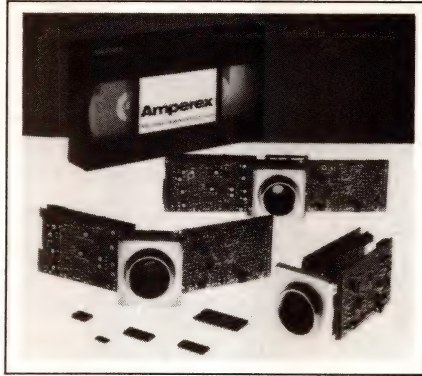
Integrated Micro Products, Number One Industrial Estate, Medomsley Rd, Consett, County Durham DH8 6TJ, UK. Phone (0207) 503481. TLX 537747.

Circle No 389

VIDEO MODULE

- Based on the company's solid-state image sensors
- Sensors' image can achieve intensity of 0.05 lux

The CCD video module is a video imaging system based on the company's solid-state image sensors (SSIS). It consists of an SSIS with



full drive, preprocessing, video-processing, and power-supply circuits. The two basic versions, models 56473 and 56474, for 525- and 625-line TV systems, respectively, meet EIA or CCIR standards. The unit utilizes the NXA1011, -1021, -1031, and -1041 solid-state image chips that operate on the frame-transfer principle, where each field of the picture frame is integrated within a photosensitive imaging region. CCD shift registers transfer the field data into storage during

vertical blanking. The data is then clocked out serially to produce the video signal. The sensors can provide recognizable images with a light intensity as low as .05 lux. From \$500 to \$600.

Amperex Electronic Co, Imaging Products Group, Slatersville, RI 02876. Phone (401) 762-3800.

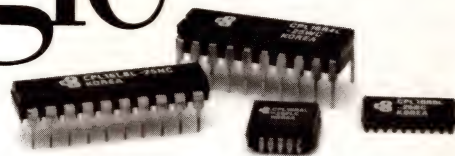
Circle No 390

DISK DRIVES

- 42M to 168M bytes of storage in 3½-in. sizes
- Interfaces for SCSI, IBM PC/AT bus, and ESDI

The ProDrive Series consists of 10 3½-in. disk drives with formatted capacities, ranging from 42M to 168M bytes. A variety of interfaces include a SCSI, an IBM PC/AT bus, and an ESDI. All drives in the series have average access times of 19 msec or less. A Discache buffer-

Samsung's CMOS Programmable Logic





management system decreases disk transaction times as much as 50%, resulting in an effective seek time of 12 msec in many applications. The drives' MTBF is rated at 50,000 hours. Evaluation units for the 42M- and 84M-byte drives with integrated SCSI controllers are available. The units have a synchronous transfer rate of 4M bytes/sec and an asynchronous transfer rate of 2M bytes/sec. 42M-byte version, \$520;

80M-byte version, \$845.

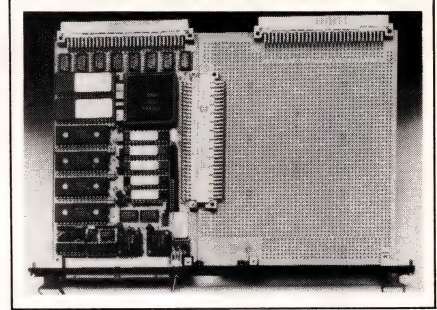
Quantum Corp., 1804 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1100. TWX 910-338-2203.

Circle No 391

CPU CARD

- Runs a 68070 μ P on a single-Eurocard board
- Allows daughter-board expansion

The SAC-700 single-Eurocard CPU board for VME Bus systems runs a 68070 μ P (a 68000-compatible processor with an on-chip DMA controller and a memory-management unit). Four 32-pin JEDEC sockets with battery backup are provided for CMOS static RAM, and two 32-pin sockets are provided for EPROM. The entire RAM area is dual-ported to the VME Bus and to the processor's local bus. The board also has two synchronous/asynchro-



nous serial I/O ports, one additional asynchronous serial I/O port, and a 16-bit parallel I/O port. An expansion connector, which carries the 68070's data, address, and control buses allows you to add daughter boards to the CPU card. An alternative version with a right-angle expansion connector allows you to mount an expansion board in the same plane as the CPU board behind a 6U front panel. The board's VME Bus interface has system-controller and slot-1 functions. From \$595.

Eltec Elektronik GmbH, Gali-

CPL™ replaces bipolar PALs® and cuts power.

Now you can directly replace the bipolar PALs in your existing design with Samsung CPL devices, and cut your power consumption 70%. There are no new development tools and no redesign required. And, best of all, there's no additional cost.

Unlike bipolar PALs, our UV-erasable CPLs are 100% factory tested to assure you of top reliability. This reprogrammability feature lets you prototype designs before committing to production. And a special security bit prevents unauthorized duplication.



CPL Starter Kit for new designs.

Special software created by P-CAD for Samsung's

CPL Starter Kit lets you start designing quickly with our CPLs. The Kit includes the powerful CUPL software development package supporting both Samsung CPL20 and CPL24 devices, a CUPL manual, a CPL data book, and CPL samples. This easy-to-use kit is designed to work with any IBM PC XT/AT or compatible system, and costs only \$220.

CPL PARTS LIST

CPL 20:	CPL24:
CPL16L8	CPL20L8
CPL16R4	CPL20L10
CPL16R6	CPL20R4
CPL16R8	CPL20R6
	CPL20R8
Speed options: 25 nsecs, 35 nsecs	
Power options (Icc max.): 45 mA, 70 mA	
Packages: PDIP, Windowed Cerdip, PLCC, SOIC	

CPL DEVELOPMENT SUPPORT

Device Programmers:	Development Software:
Data I/O	ABEL™
Digelec	CUPL™
Kontron	PALASM*
Oliver Advanced Engineering	PLDesigner™
Stag Microsystems	
Varix	

To order samples, a data book, or your CPL Starter Kit, call or write Samsung CPL

Marketing at
408/434-5400.

Setting the pace.

© 1988 Samsung Semiconductor, Inc. CPL is a trademark of Samsung Semiconductor, Inc. PAL and PALASM are registered trademarks of Monolithic Memories, Inc. CUPL is a trademark of Personal CAD Systems, Inc. IBM is a registered trademark of International Business Machines, Inc. ABEL is a trademark of Data I/O. PLDesigner is a trademark of MING, Inc.

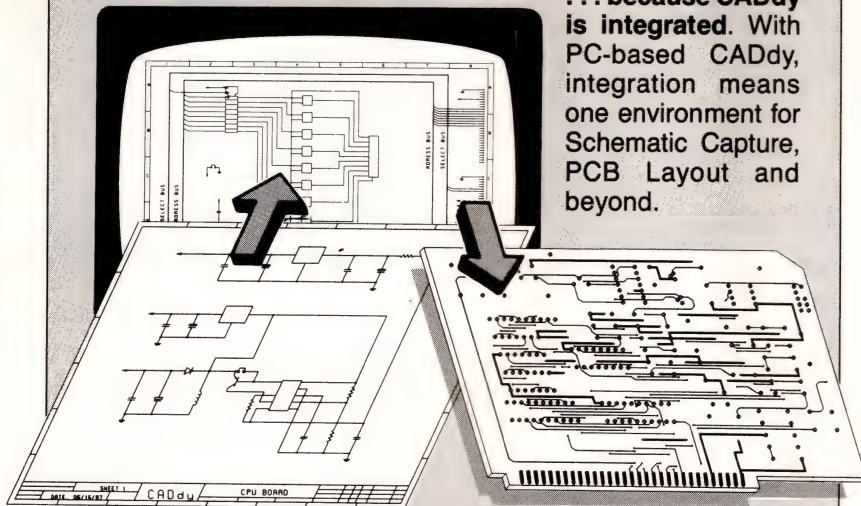


SAMSUNG

Semiconductor
3725 North First Street
San Jose, CA 95134-1708

CIRCLE NO 30

Well-Connected



... because CADdy is integrated. With PC-based CADdy, integration means one environment for Schematic Capture, PCB Layout and beyond.

- Features include symbol selection, dynamic placement, auto-naming/numbering, BOM/Netlist, board pin/gate swapping with back annotation.
- CADdy manual routing is effective for analog and multi-layer boards.
- Optional Autorouters from 4 to 16 to 22 layers, gridless, rip-up retry, each with DRC and SMD capabilities.
- CADdy has a screen menu interface with programable function keys; unlimited zooms, grids, trace widths,

pads, text sizes, hatch/fill, dynamic dragging/rubberbanding, macros, EMS.

- Optional 2D/3D mechanical for packaging design.
- Available on XT, AT, 386, PS/2 with co-processors and a wide range of graphic cards.
- Major pen plotters, laser printers, Gerber and Excellon are supported.

Now that's integration ... to help you manage your projects and stay **well-connected**.

CADdy Corporation

3401 Algonquin, Suite 340
Rolling Meadows, IL 60008

Call (312)394-7755 or 1-800-CADdy 11

CADdy

CIRCLE NO 31

DID YOU KNOW?

Half of all EDN's articles are staff-written.

EDN

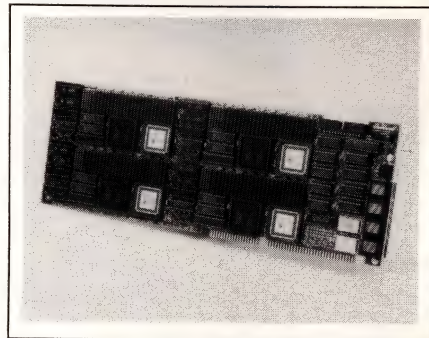
COMPUTERS & PERIPHERALS

leo-Galilei-Strasse 10, 6500 Mainz 42, West Germany. Phone (06131) 50630. TLX 04187273.

Circle No 392

American Eltec Inc, 569 S Maringo Ave, Pasadena, CA 91101. Phone (818) 449-1558.

Circle No 393



NETWORK BOARD

- Four complete PCs on one IBM PC/AT add-on card
- Connects to PC, ASCII, and ANSI terminals

The QuickLink-IV 4-user network on one IBM PC/AT add-on board has four complete PCs, each of which connect to terminals or modems via RS-232C or RS-422 interfaces. It's plugged into a file server's bus, providing multiuser power with the ability to share files and peripherals attached to the AT computer. You can use it with IBM PC, ASCII, and ANSI terminals as well as Hercules graphics terminals. The board utilizes four NEC V40, 8-MHz μ Ps. Each processor has 768k bytes of no-wait-state memory. The board draws 2.5A when supporting four users. Networking software includes Netware 286 and Novell's 4-user ELS. If you want to serve more than four users, just add another board. \$2295.

Intercontinental Microsystems, 4020 Leaverton Ct, Anaheim, CA 92807. Phone (714) 630-3714. TLX 821375.

Circle No 394

KEITHLEY ON SWITCHING:

IT'S IN THE CARDS

Our line of 18 signal switching cards is the widest variety anywhere, so you can configure a system to match your signal types without sacrificing system performance▲

SIGNAL INTEGRITY

To get the most from your test system, you must make sure your signals are switched without attenuation, distortion or alteration by the switching and interconnect▲ Since Keithley has more switching cards than any one, you can be assured of signal integrity, no matter what the test▲ Choose from:

Matrix	Most flexible
Scan/Multiplex	1, 2, or 4 pole switching
Sensitivity	Currents to 40fA, voltages to 30nV
High Level	Currents to 5A, voltages to 1000V
Bandwidth	Frequencies to 500MHz
Temperature	Thermocouple cards with $<1\mu\text{V}$ offset and built-in reference
Special Applications	Hall effect, nanovolt switching, Kelvin switching, universal adapter

Each of these switching capabilities is referenced in our new Switching Handbook▲

SYSTEM INTEGRATION

Keithley switches let you customize applications by mixing cards in two or 10-slot mainframes▲ For larger systems, you can connect up to five mainframes and program them at one IEEE-488 address▲

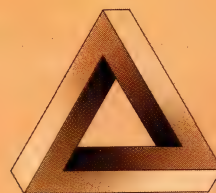
Keithley switching further simplifies system integration with digital I/O, triggers in/out, relay setup memory, inspect mode for determining relay configuration, and more▲

SYSTEM PERFORMANCE

Our products are designed for compatibility, and you'll find the proof in easier system integration and smoother performance▲ And in addition to switching, we also supply the full range of programmable measurement and source instrumentation for many test requirements▲ Plus, our Application Engineering Department is always available to help you select the right instruments and configure them for peak system performance▲

Keithley Instruments Inc., 28775 Aurora Road, Cleveland, Ohio, 44139▲ (216) 248-0400▲

Call or write the Information Center for more on Programmable Switches, Sources, and Measurement instrumentation▲ Then find out how to receive your free copy of Keithley's new Switching Handbook with useful information and practical guidelines on getting maximum performance from your test system▲

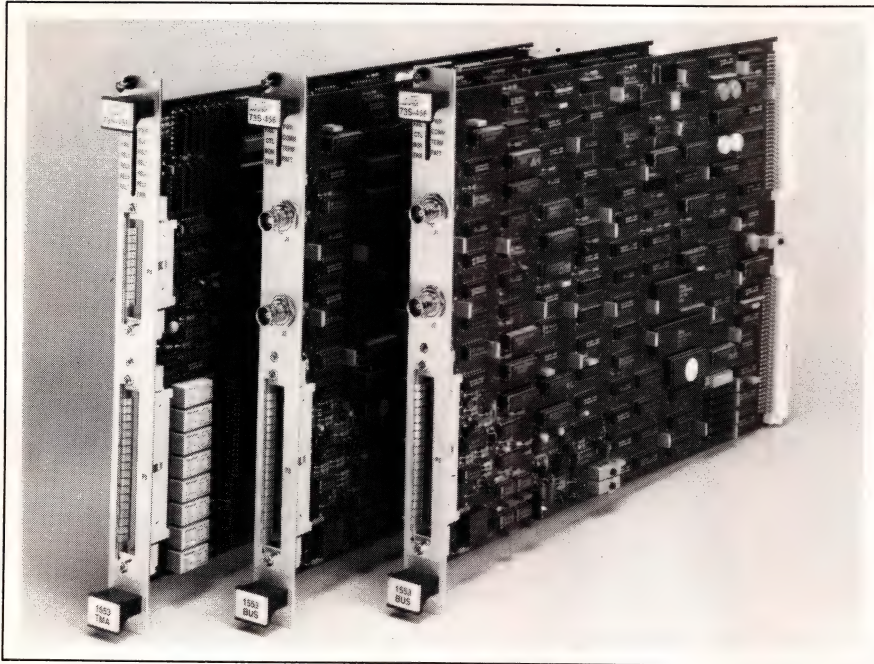


SOURCE • MEASURE • CONNECT

KEITHLEY

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS



MIL-STD-1553 TESTERS

- Plug into VXI bus
- Comply with USAF Mate guides

The 73S-456 is a 2- to 8-channel emulator/tester for the MIL-STD-1553 bus, whereas the 73A-453 multimodal simulator/tester can test all devices that conform to MIL-STD-1553. Both board-level products comply with the US Air Force's Mate (modular automatic test equipment) guidelines and plug into VXI (VME extensions for instrumentation) bus backplanes, such as the vendor's 73A system. The 73A system accommodates cards that use only the VXI bus's P1 connector or that also use its P2 connector.

Under the VXI standard, the 73S-456 and 73A-453 are considered message-based devices. The 73S-456 tests 1553 bus controllers and remote-terminal simulators and can also serve as a bus monitor that stores 30k words/channel max. You can program the 73A-453 to act as a bus controller, remote terminal, or bus monitor; it allows control of message formats. 73S-456, \$7995; 73A-453, \$3200. Delivery, 10 to 12 weeks ARO.

Colorado Data Systems Inc., 3301 W Hampden Ave, Unit C, Englewood, CO 80110. Phone (800) 237-2831; in CO, (303) 762-1640. TWX 910-933-0193.

Circle No 400

80386 ANALYSIS TOOLS

- Analyze software performance nonstatistically
- Operate at 20 MHz with no wait states

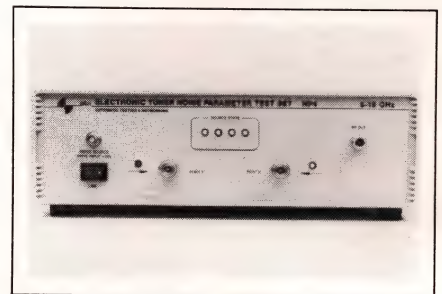
You use the 80386 probe and disassembler with the vendor's SAW (software analysis workstation) to trace, optimize, and verify

software performance in real time on your target system's hardware. The probe supports the 80386's real and protected modes. When used with the vendor's interactive state analyzer or Softanalyst tools, it allows target-system operation at 20 MHz with no wait states or at 25 MHz with one wait state. The probe supports pipelined and nonpipelined

addressing and 16 or 32-bit dynamic bus sizing. The nonstatistical performance analyzer captures bus activity and displays it in 80386 assembly code. In multiprocessor systems, a time-aligned trace display allows you to correlate the activity of the processors. 80386 probe, \$2500; SAW, without host IBM PC or compatible computer, \$24,690.

Northwest Instrument Systems Inc., 19545 NW Von Neumann Dr, Beaverton, OR 97075. Phone (503) 690-1300.

Circle No 401



NOISE TEST SET

- Covers 6 to 18 GHz
- Tests with 16 selectable source impedances

The NP4 618 noise-parameter test set covers 6 to 18 GHz and can function under IEEE-488-bus control. It automatically determines the noise and the available gain of linear two-port devices driven from 16 selectable source impedances. A tuned power meter, which doesn't have any moving parts and which operates under μ P control, calculates the noise power. The electronic load switches in less than 1 msec. The vendor reports that units remain in calibration for over a year. \$56,160. Delivery, 14 weeks ARO.

Automatic Testing and Networking Inc., 600 W Cummings Park, Suite 3400, Woburn, MA 01801. Phone (617) 935-3420.

Circle No 402

POWER!

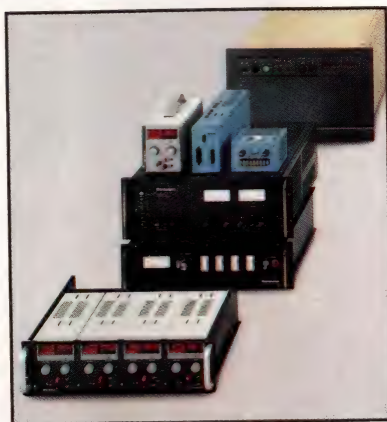
This impressive lightning display is power in its most primitive state. At Sorensen, we have devoted ourselves to the task of developing products that will effectively harness, manage and transmit power. The result of this endeavor is a comprehensive line of both high quality laboratory and industrial power supplies.

For example in our laboratory line we offer a complete selection of resistance, voltage and IEEE-488 programable power instruments. These include:

The XT Series. Fast, programmable 60-watt linear power supplies with low cost, low noise and low ripple, digital and analog display. Available in over 30 standard models and more than 1,500 user-specified configurations.

The QRD Series. Offering high-speed, high-performance with low noise. Available in 6 models, all half-rack mountable and free standing. 5 fully adjustable voltage and current ranges from 0-15 to 0-60 Vdc from 0.75 to 4 amps.

The SRL Series. Medium-power, high-efficiency, programmable, with low RMS ripple and pk-pk noise. The best selling power supply of its



type. Available in 14 models in 4 adjustable voltage and current ranges from 0-10 to 0-60 Vdc and 250 to 2100W power.

The DCR Series. This series combines over 50 models of both single and three-phase input units. This includes the DCR-T series, an exciting, highly advanced concept in power supply design with built-in OVP. These units are fully remote-controllable and provide greater

Sorensen

A Raytheon Company

5555 N. Elston Ave.
Chicago, IL 60630

power, safety and flexibility than conventional supplies.

Most Sorensen power supplies are backed with our Five Year limited parts and labor warranty.

No other manufacturer can match Sorensen's experience and reputation in power supplies, earned over the past 44 years.

If you're interested in high quality power supply performance, and want a "lightning quick response" contact us at (312) 775-0843 or simply fill in the handy coupon and return to us.

☐ Please have a representative contact me.

☐ Please send me your latest full line catalog.

Name

Company

Title

Address

City/State/Zip

Telephone ()

Mail to: Marketing Communications Dept.
Sorensen Company
5555 N. Elston Avenue
Chicago, IL 60630

EDN 5-12-88

CIRCLE NO 140

NEW SONY/TEK
CURVE TRACERS

NEW RELIABILITY. CLASSIC LINE.

Durable, strong, and hardworking. Like their predecessor, the 576, the new 370 and 371 deliver day-in, day-out dependability. But they bring you much more than that.

Smooth, fast, and powerful. Both the 370 and 371 have an easy-to-use front panel and time-saving features like no-wait hardcopy, push-button sequenc-

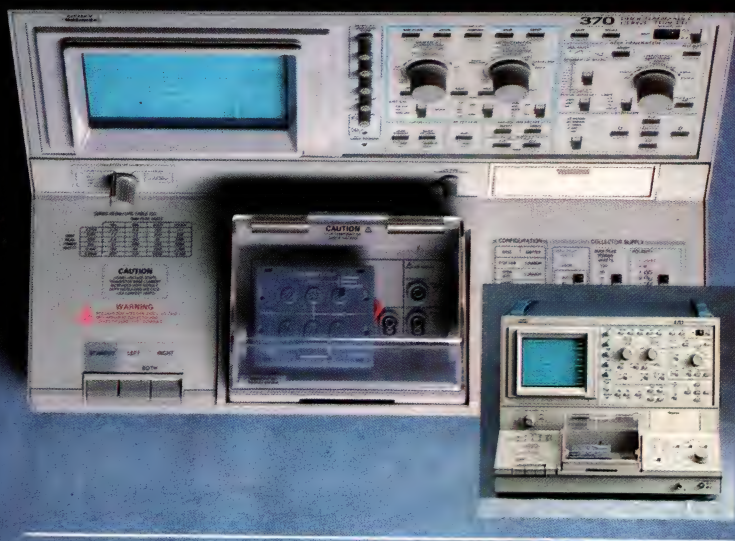
ing, and standalone or GPIB programmability. And the 371 can handle up to 3000 watts.

Part of a truly classic line.

The 370 and 371 combine the best of what's new with what's proven—including the Tektronix commitment to industry-leading service and support. To learn more, contact your local Tek representative, or call

1-800-835-9433, ext. 170.

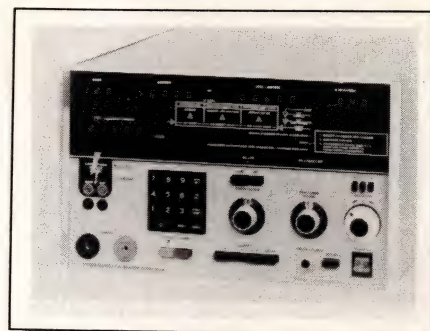
RANGE	370	371
Max Peak Voltage	2000V	3000V
Peak Current Pulsed	20A	400A
Max Peak Power	220W	3000W
Price	\$17325	\$19950



Tektronix
COMMITTED TO EXCELLENCE

Copyright © 1987, Tektronix, Inc. All rights reserved. SCA-833

INSTRUMENTS



POWER CALIBRATOR

- Features $\pm 0.015\%$ error spec at 0.01 power factor
- Calibrates instruments that can measure 35 kW

The 800LPF is a standard for calibrating instruments that measure power at ac line frequencies. It works with instruments that accept 10 to 700V rms and 100 mA to 50A rms (ie, 1W to 35 kW) at 50, 60, and 400 Hz. It maintains its $\pm 0.015\%$ error spec at power factors as low as 0.01. You can obtain units with an IEEE-488 interface. \$12,000 to \$14,000. Delivery, 90 to 120 days ARO.

Rotek Instrument Corp, 390 Main St, Waltham, MA 02154. Phone (617) 899-4611.

Circle No 403



3 1/2-DIGIT DMM

- Measures 220V with 0.1V precision
- Fits in a shirt pocket along with probes

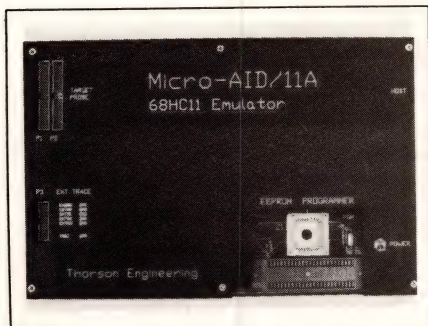
The DM79 can provide ten times the resolution supplied by 3 1/2-digit me-

INSTRUMENTS

ters on many measurements. On any range, it offers a full-scale display that extends to 3199 counts instead of the more commonly provided 1999 counts. This greater number of counts contributes to the instrument's improved resolution; for example, it permits the meter to measure 220V ac with a resolution of 0.1V rather than 1V. The credit-card-size unit sports five dc-voltage ranges from 0.32 to 400V; four ac-voltage ranges from 3.2 to 400V; and six resistance ranges from 320 to 3.2 M Ω . The meter meets UL94V-2 flammability requirements. It features an overvoltage protection rating of 700V and a case whose insulation is rated at 2 kV. When in its carrying case, the meter will withstand a fall of as much as three feet without sustaining damage. The range switch's life expectancy exceeds 2000 rotations. \$49.95.

Beckman Industrial Corp., 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3240.

Circle No 404



68HC11 DEVELOPER

- Includes ICE and EEPROM programmer
- Plugs into PC Bus

The Micro-Aid/11A board plugs into the IBM PC Bus to provide complete development support for the Motorola 68HC11 μ P family. The board incorporates an EEPROM programmer with zero-insertion-force sockets for EEPROMs in DIPs or leadless chip carriers, and an in-circuit emulator (ICE) that emulates the MC68HC11A8 in both sin-

NEW SONY/TEK CURVE TRACERS

HARD COPY. NO WAITING.

The new 370 and 371 curve tracers give you **hardcopy without tying up your system**. You keep right on working—measuring up to 3000 watts with the 371, programming the 576-like front panel or over the GPIB, and using push-button sequencing to instantly call up any of sixteen different setups or comparison curves.

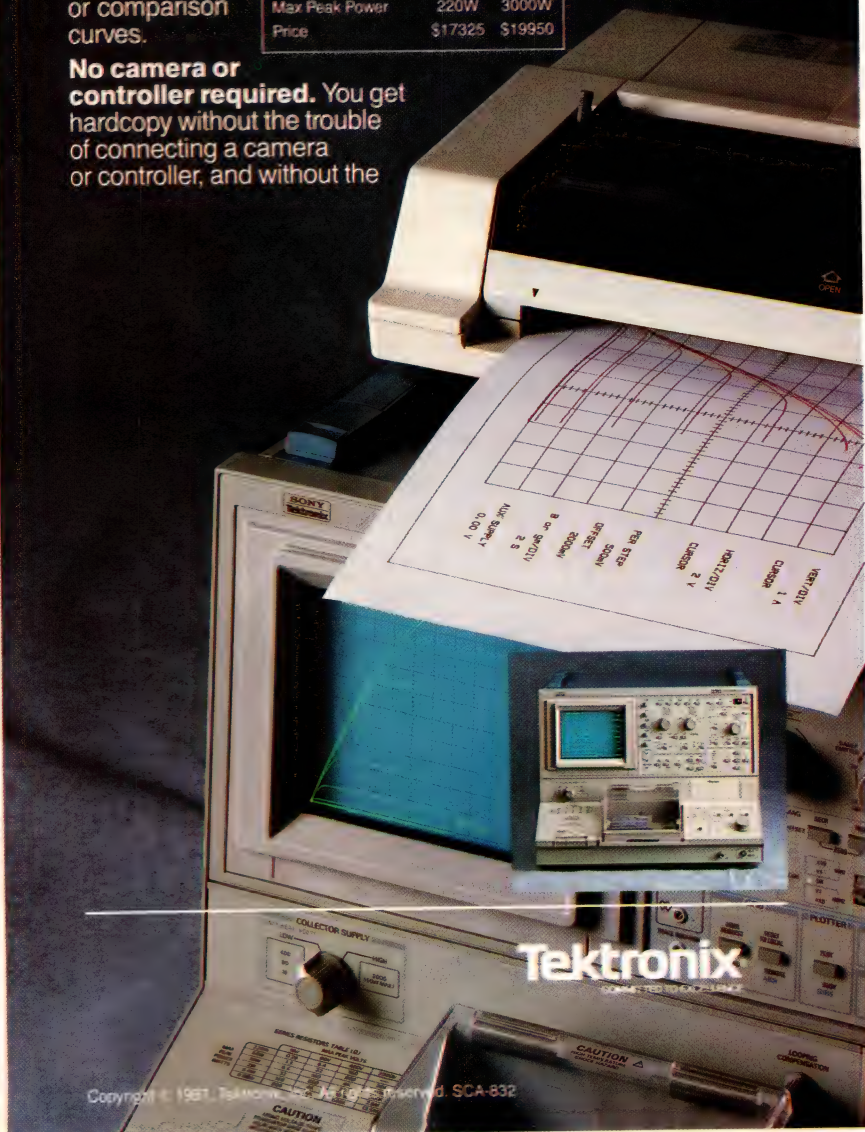
RANGE	370	371
Max Peak Voltage	2000V	3000V
Peak Current Pulsed	20A	>400A
Max Peak Power	220W	3000W
Price	\$17325	\$19950

No camera or controller required. You get hardcopy without the trouble of connecting a camera or controller, and without the

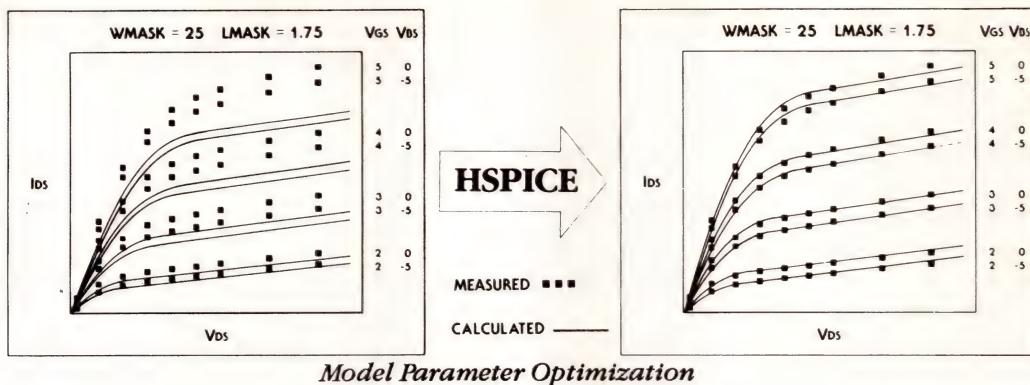
continuing cost of film. For example, you can use the Tek HC-100 plain-paper plotter, priced at only \$775.

With Tektronix, you can count on quality, reliability, and the support you need. For more information, contact your

local Tek representative or call 1-800-835-9433, ext. 170.



Copyright © 1987, Tektronix, Inc. All rights reserved. SCA-832



Optimizing HSPICE

Meta-Software announces Optimizing HSPICE, incorporating full optimization into the HSPICE circuit simulator.

HSPICE is now a multi-target optimizer that supports all SPICE and HSPICE models. Optimization is included with HSPICE as a new feature, and is available to all HSPICE customers on Software Maintenance at no extra charge.

HSPICE is an integrated solution, optimizing not only DC currents for models, but also capacitance for AC analysis and transient parameters for transient analysis.

HSPICE effectively replaces the functionality of SUXES-10 with full multi-target optimization capabilities. No pre- or post-processing is required.

HSPICE is the result of more than ten years of research in both optimizing algorithms and in user interface. The optimizing function has been integrated into the core of HSPICE, resulting in optimum efficiency. Optimizing HSPICE results will always agree with HSPICE circuit simulation.

Special features of Optimizing HSPICE include:

- Incremental optimization technique, DC, AC and transient optimization
- Uses HSPICE language format
- Model, device, subcircuit and circuit level parameters may all be optimized
- Optimizing Results Targets include Device Currents, Capacitance, Power, Time Delays, Unity Gain Frequency and S Parameters

Meta-Software also offers an extensive Discrete Device Library, HSPLOT graphics post-processor, ATEM process characterization system, Discrete ATEM for characterizing BJTs, MOSFETs, JFETs, HEXFETs and diodes, MetaTestchip™, and the Circuit PathFinder path timing analysis tool.

Other new features of HSPICE:

- | | |
|----------------------------------|-------------------------------------|
| • Monte Carlo Analysis | • Measure Statement |
| • Pole Zero Analysis | • Multi-Gamma Model for MOS 6 Level |
| • S Parameter Output | • Small Signal Network Analysis |
| • Mixed Domain Analysis | • ALTER Statement |
| • Instantaneous and RMS power | • Improved BSIM Model |
| • Individual element temperature | • Data Statement |

Meta-Software, Inc. • 50 Curtner Avenue, Suite 16 • Campbell, CA 95008
Phone (408) 371-5100 • FAX (408) 371-5638 • TLX 910-350-4928

TEST & MEASUREMENT INSTRUMENTS

gle-chip and expanded multiplexed modes. The ICE includes 64k bytes of overlay RAM and allows 65,536 breakpoints. The trace memory is 2048 32-bit words. The software shipped with the board includes a symbolic debugger, a crossassembler, and a program editor. The software that supports the programmer allows you to fill and examine memory and to erase, copy, and verify PROMs. \$2395.

Thorson Engineering Co., 6225 76th St SE, Snohomish, WA 98290. Phone (206) 334-4214.

Circle No 405



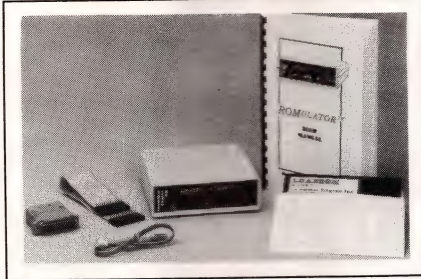
TEMPERATURE METERS

- Cover 200 and 1200°F and 200 and 650°C
- Provide automatic overrange and polarity indication

The 2871 and 2872 are 3½-digit temperature-measuring panel meters that accept type J thermocouples terminated in plug-in connectors and that include cold-junction compensation. The 2871 runs off 120V ac; the 2872 runs off 5V dc. The vendor offers each with a choice of four calibration factors: 0 to 200°F, 0 to 1200°F, 0 to 200°C (with accuracy specified from -30 to +200°C), and 0 to 650°C. The accuracy equals 0.2% of reading plus 1.8 to 2.5°, depending on the range. The units perform within specifications when the thermocouple's resistance is ≤50Ω (the equivalent of 50 ft of type J thermocouple wire), and they withstand 250V between the thermocouple and power-line ground. \$159.

Simpson Electric Co., 853 Dundee Ave, Elgin, IL 60120. Phone (312) 697-2260. TLX 722416.

Circle No 406



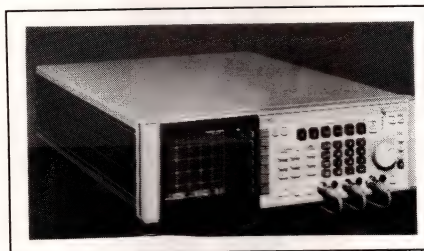
ROM EMULATORS

- Support access times as short as 50 nsec
- Emulate 1M-byte devices

The Romulator family of ROM emulators now includes a unit that permits access times as short as 50 nsec and another that emulates 1M-byte devices. Yet another unit allows the target system to write into the ROM emulator. The emulator family supports 8-, 16-, and 32-bit target systems. The emulators are self-contained; they don't use an I/O slot in the host computer. The units communicate via an RS-232C port. You can obtain host software for MS-DOS, Unix, VMS, and Macintosh operating systems. Eight-bit versions, \$375 to \$565; 16-bit versions, \$590 to \$965; bidirectional versions, \$575 to \$1225; 1M-word versions, \$710 to \$1645.

Grammar Engine Inc., 1021 Tipton Ct, Westerville, OH 43081. Phone (614) 882-6366.

Circle No 407



MODULATION ANALYZER

- Performs vector analysis from 50 to 200 MHz
- Calibration corrects quadrature and balance errors

The HP 8981A vector modulation analyzer utilizes a broadband, coherent, in-phase/quadrature demod-

IEEE-Z

IOtech has the widest selection of *easy-to-use* interfaces & software for IEEE 488 (GPIB/HPIB) systems.

• Instrument & plotter controllers (internal & external) for PCs, PS/2s, & Macintosh

• Converters from IEEE to RS-232/422, digital I/O, modem, real-time clock, SCSI, & analog I/O

• IEEE bus extenders via RS-422 or fiber-optics

• 512K IEEE data buffers & expanders

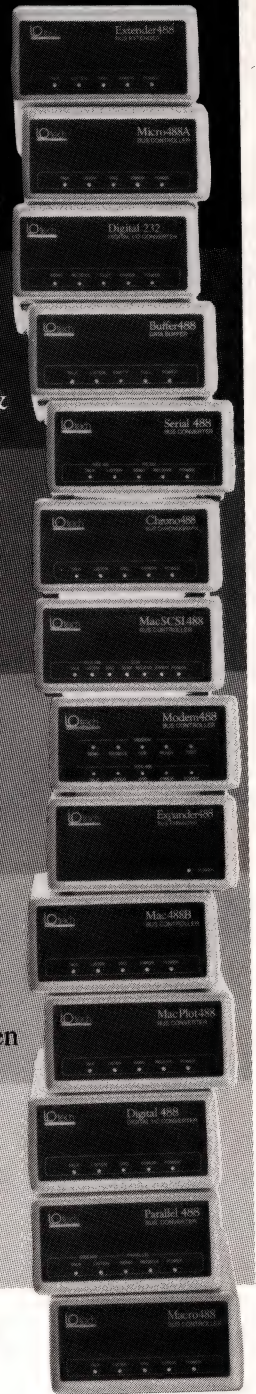
• Software for IEEE control from languages & Lotus 1-2-3®

• Menu-driven graphics & analysis software

• 30 day money-back guarantee

• 2 year warranty

• Call for your **FREE Technical Guide**



IOtech...the choice is easy

IOtech

(216) 439-4091 Telex 6502820864 Fax (216) 439-4093

25971 Cannon Road • Cleveland, Ohio 44146

London (0734) 86-12-87 • Paris (1) 34810178 • Zurich (01) 821 944

Milan (02-4120360) • Linkoping 013 11 01 40 • Amsterdam 01830-35333

Sidney (2) 452 3831 • Munich, and other European, North African, and

Middle East countries not listed (089) 710020.

CIRCLE NO 34



19" Racks Made by Professionals. For Professionals.

For 20 years Knürr AG has been a major supplier in the area of 19" systems.

The programme includes 19" racks, 19" cabinets, 19" consoles, 19" card-frames, 19" chassis, 19" fan units and many more products. The excessive range of accessories enables the economical installation of your electronics.

The latest introduction of the modular system Chasseleon® — a benchcase which is also a full 19" chassis, even on telescopic slides and on chassis runners — increases your possibilities even further.

19" systems by Knürr — a proof of competence. All over the world.



We are closer than you think:

Austria	Grothusen Ges.m.b.H., Tel. 02 22/97 25 29
Australia	Email Ltd., Tel. 03/5 44 82 44
Belgium	Vitronic Belgie NV, Tel. 03/3 25 27 10
Denmark	Otto Ahrens A/S, Tel. 01/71 47 44
Finland	Perel Oy, Tel. 914/2 16 00
France	Knürr S.A.R.L., Tel. 1/43 77 85 85
France (Alsace)	A. Baumann S.A., Tel. 08/8 32 60 26
U.K.	Datur Ltd., Tel. 02/76 68 12 12
Greece	Nicolaos Asteriadis, Tel. 0 31/27 86 92
India	Elcopak, Tel. 02 12/8 48 46
Israel	Alexander Schneider Ltd., Tel. 03/37 20 89
Italy	Forind Avio Elettronica S.R.L., Tel. 02/2 14 15 11
Japan	Y.H. Supply Co. Ltd., Tel. 4 42/28 51
Netherlands	Vitronic Holding B.V., Tel. 01/62 05 14 40
Norway	Jana Tekniske A/S, Tel. 02/68 53 50
Pakistan	Qaim-Ale-Mohammad Corp., Tel. 7 27 19
Portugal	Sociedade Zickermann S.A.R.L., Tel. 36 90 65
South Africa	Advanced Semiconductor Dev. (PTY) Ltd., Tel. 0 11/8 02 58 20
Spain	S.I.G., Tel. 01/8 88 97 90
Sweden	Garam Elektronik AB, Tel. 08/7 10 03 40
Switzerland	Knürr AG, Tel. 01/8 25 07 07
U.S.A.	Dacobas Inc., Tel. 8 05/5 26 77 33

CIRCLE NO 142

Knürr AG

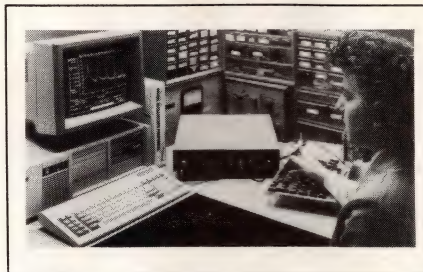
P.O. Box 82 03 69 · Schatzbogen 29 · D-8000 München 82
Tel. 0 89/42 00 40 · Telex 5 29 608-10 knr · Telefax 0 89/42 00 41 18



ulator to cover the 50- to 200-MHz IF and carrier frequency range. The instrument uses a statistical calibration routine to enhance its accuracy, performs all the functions of the vendor's 8980A vector analyzer, and includes a front-end vector demodulator that handles a 35-MHz in-phase/quadrature bandwidth. The calibration algorithm corrects for quadrature-angle error, in-phase and quadrature-phase channel balance, and dc offsets. The calibration reduces the quadrature error to $\pm 0.5^\circ$, the in-phase/quadrature channel balance to ± 0.1 dB, and the dc offset to $\pm 1\%$ of full scale. This accuracy yields an image rejection spec of 50 dB. The unit can display in X-Y, "constellation," and "eye" modes. \$29,000. Delivery, 12 weeks ARO.

Hewlett-Packard Co., 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local office.

Circle No 408



ANALYZER/SCOPE

- Has two channels, each with a 12-bit ADC
- Displays 1024-point FFT spectrum in real time

The R350 is a 2-channel FFT spectrum analyzer and digital oscilloscope based on an IBM PC or compatible computer. It features a 1-MHz max sampling speed and a 500-kHz max bandwidth. Each of its channels has its own 12-bit analog-to-digital converter, 32k-word storage buffer, and digital signal processor. The analog inputs are differential for rejection of common-

mode noise, and each channel incorporates an anti-aliasing filter. You can select sensitivities from 1 mV/div to 20 V/div. The trigger modes include pretriggering, post-triggering, internal triggering, and external triggering. You can average from one to 64 spectra, and you can display spectra on a linear or logarithmic frequency scale. \$3995.

Rapid Systems Inc., 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311. TLX 265017.

Circle No 409

80C86 EMULATOR

- Zero-wait-state emulation at μ Ps' max clock speeds
- State-machine triggering and control

The ES 1800 host-independent, in-circuit emulator emulates the 80C86 and 80C88 CMOS μ Ps from Harris and Intel. It performs transparent,

Sports Card

Shift into high gear with the high-performance, quick-handling HK68/V2E card. This 32-bit single-board microcomputer is well-equipped to handle even the most challenging dedicated control tasks. Now you can have speed and versatility without sacrificing the functionality you need for sophisticated real-time applications. Standard equipment:

- Up to 25 MHz Motorola 68020 CPU ■ 4 or 16 MB of on-board DRAM with parity ■ Up to 2 MB of EPROM ■ VSB compatible high speed memory expansion bus ■ 4 serial I/O ports ■ Single 8-bit parallel port.

Optional racy features include on-board 68881/68882 FPP and SCSI interface.

HEURIKON

Take Heurikon's HK68/V2E for a trial run today.
Call toll-free: 800-356-9602 (ext. 502).
Telefax: 608-251-1076
3201 Latham Drive ■ Madison, WI 53713

BREAK T H R O U G H

New microlasers are expanding and refining laser applications through advanced diode-pumped, solid-state technology.

Amoco Laser Company's microlaser technology represents a quantum leap forward for laser light sources. Finally, a low noise, highly efficient, compact laser is available with operating voltage and lifetime characteristics that make microlasers a practical solution for many applications.

Consider the following line of infrared microlasers. They are available for immediate shipment for a wide range of uses in testing and inspection, optical alignment, materials characterizations, metrology, process monitoring,

spectroscopy, micromachining, and microsurgery.

Product	Wavelength	Power
ALC1064-50	1064nm	50mw
ALC1064-150	1064nm	150mw
ALC1320-25	1320nm	25mw
ALC1320-75	1320nm	75mw

All of the above lasers have a diffraction limited, TEM₀₀ mode and are offered with linear or random polarization. A line of precision collimators is also available.

Want to learn more?

Write for our videotape which more thoroughly explains Amoco's microlaser and its uses.

Amoco Laser Company,
1809 Mill St., Naperville, IL
60540, or phone: 312-369-4190.



Amoco Laser Company

CIRCLE NO 143

real-time, zero-wait-state emulation at the μ Ps' maximum-rated clock speeds. The emulator comes with the vendor's event-monitor system, which provides state-machine triggering as well as breakpoint and emulation control. The event-monitor system allows you to break on any combination of address, data, status, pass-counter, and logic-state

fields. You can obtain the Validate/Soft-Scope high-level-language debugger and the Geneprobe symbolic debugger as options. Both debuggers run on the IBM PC/AT, PC/XT, or compatible computers. \$11,495.

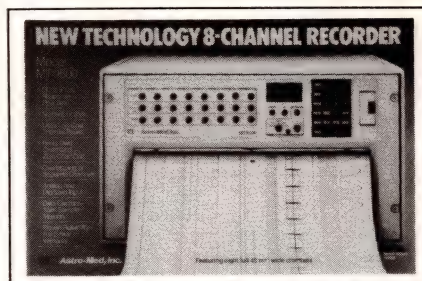
Applied Microsystems Corp., Box 97002, Redmond, WA 98073. Phone (206) 882-2000. TLX 185196.

Circle No 410

8-CHANNEL RECORDER

- *Eliminates galvanometers and styluses*
- *Has -3dB response at 5 kHz*

The MT-9500 8-channel oscillographic recorder's only moving parts are its chart drive and thermal imaging paper. It can reproduce 3-kHz analog signals with negligible attenuation; at 5 kHz, its response is -3 dB. The unit digitizes data with 12-bit precision at 32k samples/sec.



Every msec, it energizes the elements in its stationary printhead that span the highest and lowest amplitudes achieved by each signal during the last 32 samples. The printing elements are spaced 0.005 in. apart. You can select the side-by-side display of 40-mm-wide channels or the overlapping display of two groups of four channels, each in a 160-mm-wide area. The stepper-motor chart drive allows you to advance the roll or Z-fold paper, at any integer value of speed, to run at 150 or 200 mm per sec or to run from 1 to 100 mm per sec, minute, or hour. The unit prints the chart grids



Dream Card

The HK68/V30 is the card you've been dreaming of.

This fully-loaded single-board VME microcomputer combines the highly sought-after qualities of high speed and advanced on-card functionality. Now you can have high-end performance for UNIX and real-time applications. Standard equipment:

- Up to 25 MHz Motorola 68030 CPU ■ 4 or 16 MB of on-board DRAM with parity ■ Up to 1 MB of EPROM ■ 2 serial I/O ports ■ Single 8-bit parallel port ■ Mailbox interrupt support.

Optional equipment includes on-board 68881/68882 FPP, SCSI interface and Time-of-Day clock with battery back-up.

HEURIKON CORP

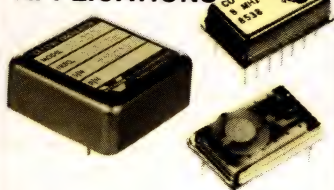
Take Heurikon's HK68/V30 for a grand tour today.
Call toll-free: 800-356-9602 (ext. 503).
Telefax: 608-251-1076
3201 Latham Drive ■ Madison, WI 53713

CIRCLE NO 36

Your One-Stop Source for...

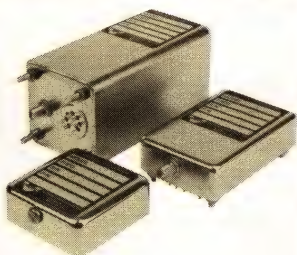
VCXOs

PHASE LOCKING APPLICATIONS



Frequency:	TTL: 32 kHz- 70 MHz HCMOS: 1 kHz- 50 MHz ECL: 8 MHz-200 MHz SINE: 8 MHz-600 MHz
Deviation:	± 30 ppm to ± 200 ppm. Permits locking onto a stable source for 10-20 years without adjustment.
Package:	0.2" high DIP, pcb mount, or chassis mount with rf connector.

LINEAR APPLICATIONS



Frequency:	2 to 600 MHz
Deviation:	± 0.01%, ± 0.03% and ± 0.1% standard. Narrower or wider deviation optional.
Linearity:	± 1%, ± 3% or ± 5%
Stability:	From ± 0.00003% to ± 0.01% using standard, temperature compensated and oven designs.

Call The
Application
Engineering
Hot Line Today!



The Crystal Oscillator Company

VECTRON LABORATORIES, INC.
166 Glover Avenue, Norwalk, CT 06850
203/853-4433. TWX: 710/468-3796

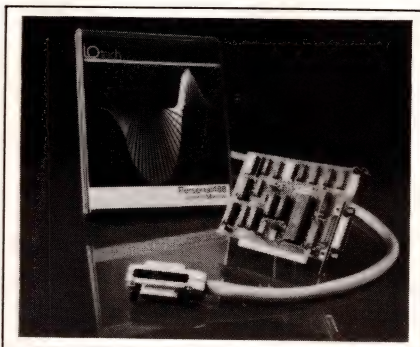
CIRCLE NO 37

TEST & MEASUREMENT INSTRUMENTS

along with the data and includes facilities for event marking, time coding, and annotation. \$12,950. Delivery, four to six weeks ARO.

Astro-Med Inc., Astro-Med Industrial Park, W Warwick, RI 02893. Phone (800) 343-4039; in RI, (401) 828-4000. TWX 710-382-6409.

Circle No 411



IEEE-488 INTERFACE

- Lets multiple boards share DMA and interrupt channels
- Eliminates repeated parameter definition

The Personal488 is a device-driver-based IEEE-488 interface for the IBM PC, PC/AT, and compatible computers. Its new software, which the vendor claims is compatible with all popular MS-DOS- and PC-DOS-based languages, lets you employ a single definition of an instrument's parameters (eg, device name, IEEE address, and terminators), and thus enables you to write code that consumes as little as 1/2 the memory needed by programs employing other approaches. When you install a driver in DOS, it remains there; you need not install it each time you use the computer. The interface-board hardware permits multiple boards to share the same DMA and interrupt channels, and a selectable wait-state generator makes the vendor's boards compatible with high-clock-speed computers that don't slow down during bus activity. \$395; board without software (for use with Asyst, Lotus Measure, and TBasic), \$295.

Iotech Inc., 23400 Aurora Rd,

Cleveland, OH 44146. Phone (216) 439-4091. TWX 650-282-0864.

Circle No 412



ASIC VERIFIER

- Accommodates 60-MHz max clock and data rates
- Uses "per-pin" architecture

The Logic Master XL-60 16- to 224-channel ASIC-prototype verification system accommodates 60-MHz clock and data rates. Its "per-pin" architecture is the same as that used in the vendor's 100-MHz system. The architecture allows the independent assignment of all system resources to any pin. The system features 100-psec edge placement and sampling resolution, 125-psec frequency resolution, and <±1 nsec skew after autocalibration. An automated fixturing system eliminates wiring and maintains a 50Ω transmission line to the device pins. The system accommodates DIPs and pin-grid-array packages. \$180,000 to \$220,000. Delivery, eight weeks ARO.

Integrated Measurement Systems Inc., 9525 SW Gemini Dr, Beaverton, OR 97005. Phone (503) 626-7117.

Circle No 413

18?? — The First Fuse

Today's Fuse

Tomorrow's Fuses

BUSSMANN SOLID MATRIX ELECTRONIC FUSES ARE READY FOR THE 21ST CENTURY.

New Bussmann solid-matrix fuses are a departure from conventional fuse design. Their solid-matrix fuse element has no surrounding air space, resulting in unique performance for electronic applications. In fact they extend the possibilities of design, previously inhibited by limited fuse performance.

■ Both Bussmann PC-Tron® and SMD Tron® (surface mount) fuses are distinguished by their excellent current limiting capability. Solid matrix construction rapidly extinguishes the arc and limits peak current in a predictable and repeatable manner when a fault occurs. Not only equipment but also circuit-board components are protected. Both fuses provide for automatic insertion and are completely sealed to withstand rigorous board washing. ■ And for designs

locked into the conventional, sub-miniature fuse footprint, Bussmann offers Microtron®—honest, reliable performance

BUSS

in a familiar package. To obtain samples and literature on PC-Tron and Microtron and advanced information on the SMD Tron, call your Bussmann Sales Engineer or contact Bussmann directly. Bussmann Division, Cooper Industries, Box 14460, St. Louis, MO 63178, 314-394-BUSS.

**TOUGH D-C APPLICATIONS?
GIVE US A CALL.**



BUSSMANN

NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS

FAX+TELEX

- Lets you use PC for both fax and telex
- Conforms to CCITT Group III standard

Proto.Fax Plus is a hardware-software package that lets you use your IBM PC or compatible as both a telex terminal and a facsimile terminal. The hardware portion consists of a full-length board that you can plug into any expansion slot of a PC that has at least 640k bytes of RAM, a hard-disk drive, and MS-DOS 3.0 or higher version. You'll also need a CGA, EGA, or Hercules graphics adapter, and an IBM Graphics (dot-matrix) printer or a Hewlett-Packard or QMS laser printer. The software provides extensive on-line help and is menu-driven for ease of use. Its features include a call directory and automatic dial and answer. It can receive documents in background mode while you're working on another applications program in the foreground. A built-in editor lets you create text messages (you can also use a standard word pro-



cessor) and store them on disk for later transmission via telex, fax, or electronic mail. Fax transmission takes place at 9600 bps, with automatic fallback to lower speeds over noisy lines. The software works with any of the major telex carriers including FTC, Graphnet, ITT, MCI International, RCA, TRT, and

Western Union. Three versions of the package are available: Proto.call (telex only) or Proto.fax (fax only), \$975 each; Proto.fax plus (both fax and telex), \$1595.

American Teleprocessing Corp., 10681 Haddington, Houston, TX 77043. Phone (713) 973-1616. TLX 774444. **Circle No 415**

CAE INTERFACE

- Between HP and other CAE systems
- Based on EDIF 2 0 0

The 74220A bidirectional EDIF (Electronic Design Interchange Format) interface lets you transfer schematic-capture data between the vendor's CAE tools and other, dissimilar, CAE tools. This standard interchange format lets you accept symbol libraries from ASIC vendors, for example, and return information about the finished design to the foundry. Version 2 0 0 of EDIF guarantees upward compatibility with future versions of the standard. The vendor's interface also works with data in EDIF 1 1 0 format, which the vendor's Printed

Circuit Design System and Engineering Graphics System uses. \$15,000. Delivery, eight weeks ARO.

Hewlett-Packard Co., Customer Information Center, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local office.

Circle No 416

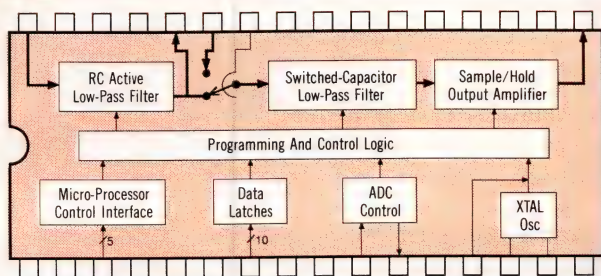
EXPERT-SYSTEM SHELL

- Runs in protected mode on 80386-based μ Cs
- Forward- and backward-chaining

TWACE, a tool for creating rule-based expert systems, allows a domain expert to verify the knowledge base without having to learn any

programming language. The program's rule syntax is simple: You create rules and other knowledge-base components with the aid of a standard text editor. The tool then checks them for syntactic correctness and internal consistency, and you correct errors. After error correction, the software compiles final rules and taxonomy frames into a compact representation that the computer can load quickly. While you're building a knowledge base, you can use Why commands to find out the chain of reasoning that makes the program ask certain questions, and How commands to learn how the tool derived a particular result. (The package provides extensive on-line help on how to use the various commands.) This tool

TOGETHER WE FOUND THE ANSWER...

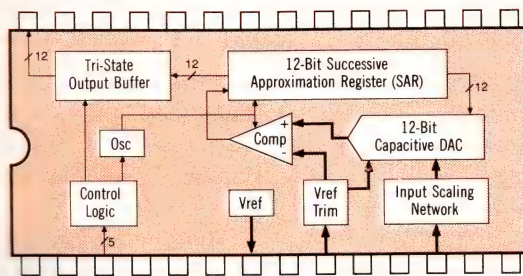


Analog In

HSCF24040

- 7th Order Monolithic Low-Pass Filter
- 85dB Dynamic Range
- Internal RC Anti-Alias Filter
- Sample/Hold Output Amplifier
- Low Power CMOS Technology

Ideal for 12-bit data acquisition systems, the HSCF24040 is unsurpassed as an anti-alias filter or a DAC output smoothing filter. The cutoff frequency of the active RC and switched capacitor sections is digitally programmable from 78Hz to 20kHz. The sample/hold rate and dc gain of the output amplifier are also programmable. Internal clocking of the HSCF24040 is controlled by an external reference clock or an optional crystal. This remarkable filter has less than 0.1dB passband ripple and >72 dB of stopband attenuation, yet requires no external components and consumes less than 150mW of power!



12-Bits out

HADC574Z/HADC674Z

- 12-bit Monolithic CMOS A/D Converter
- Improved 574/674 Alternate Source
- Transparent Sample/Hold Input Circuit
- Fast Conversion - 15 μ s-674, 25 μ s-574
- Low Power CMOS Technology

The HADC574Z and HADC674Z herald major performance breakthroughs. Honeywell's state-of-the-art BiCMOS process makes it possible to use ratioed capacitors instead of a traditional R-2R DAC in the HADC574Z/HADC674Z successive approximation A/D converters. The result is a built-in sample/hold function that allows sampling signals to 5kHz without an external sample/hold amplifier. Also, transient noise on the analog input during conversion has been eliminated and **no negative power supply** is required. Even with all of these features, power consumption is less than **150mW!**

Signal Processing Technologies (SPT) has created a state-of-the-art product line that includes leading-edge DSP products, flash A/D converters with 10-bit 50MSPS (million samples per second) and 8-bit 125MSPS performance and high speed DACs with update rates to 400 MWPS (million words per second). SPT offers the highest performance ECL comparators, switched capacitor filters and high precision 12, 14 and 16-bit A/D and D/A converters available.

Signal Processing Technologies was established in 1983 to develop standard products for the worldwide digital signal processing and data conversion market based on Honeywell's production-proven semiconductor capability. These technologies include one micron CMOS, Bipolar and BiCMOS. In addition, an extensive amount of research and development is being conducted in sub-micron technologies.

Honeywell SPT is constantly pushing the frontiers of technology. Together, we can give your business a push.



For more Information on these and other SPT Products Call or Write:

Honeywell Inc.
Signal Processing Technologies
1150 E. Cheyenne Mountain Blvd.
Colorado Springs, CO 80906
(719) 540-3900 TELEX #452433
EASYLINK #62926148

Together, we can find the answers.

Honeywell

SIGNAL PROCESSING TECHNOLOGIES

has been available since 1985 for IBM mainframes, VAX machines, and 68000-based workstations; the current version works on the IBM PS/2 Model 80, the Compaq 386, and other 80386-based machines. The \$7500 price includes the vendor's MProlog development language (an implementation of Prolog) and two 1-week TWAICE training classes.

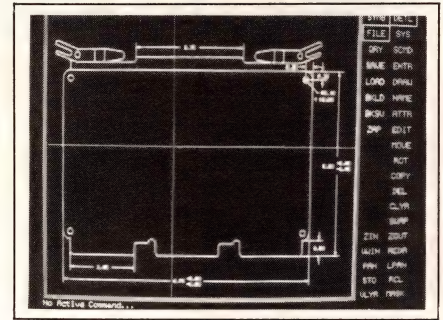
Logicware Inc., 237 Park Ave, Suite 2100, New York, NY 10017. Phone (212) 551-3536.

Circle No 417

CAE TRANSLATOR

- *Sends data between P-CAD and AutoCAD*
- *Lets you add P-CAD drawings to documentation*

The 2.0 version of PC-Trans provides bidirectional translation of data between the vendor's P-CAD CAE system and AutoDesk's Auto-



SYSTEM BUILDER

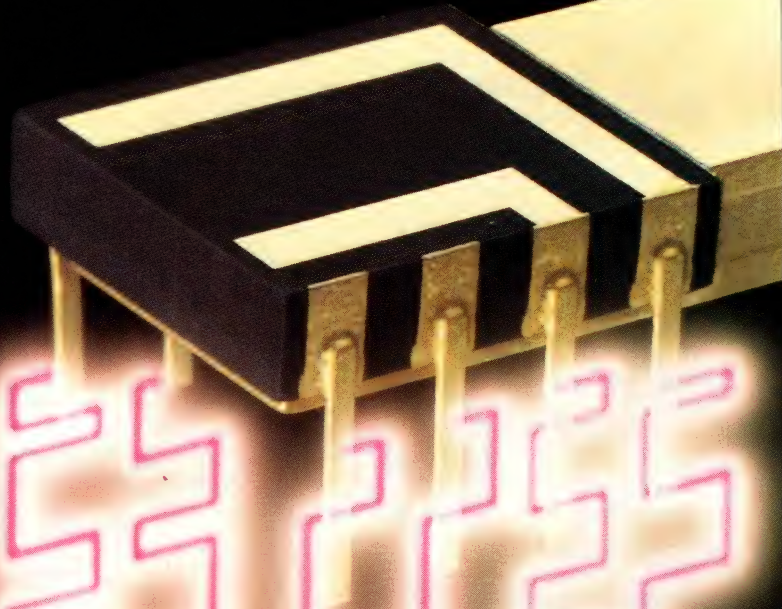
- *Automates system rebuilding upon source-code change*
- *Provides facilities for pre- and postprocessing*

PolyMake version 2.1, which is modeled on the Unix utility Make, lets you define dependencies between the programs and modules of a software system. After making changes to the source code of one or more modules, you can run the utility to recompile the changed modules and link them with unchanged modules to build the new version of the system. New features introduced in this version include special dependencies for pre- and postprocessing, new dependency types, conditional constructs, and more powerful macros than those in previous versions. According to the vendor, this version runs as much as 10 times faster than do previous versions and consumes about 40% less memory. The program is compatible with the vendor's other tools, such as the Version Control System and the Librarian. To run the program, you'll need an IBM PC or compatible that has at least 256k bytes of memory and that operates under MS-DOS version 2.0 or higher. \$149; users of previous versions can upgrade to version 2.1 for \$50.

Polytron Corp., 1700 NW 167th Pl, Beaverton, OR 97006. Phone (503) 645-1150. TLX 325800.

Circle No 418

ECL IN.



CAD system, via the AutoCAD .DXF file format. You can now create your pc-board outline with AutoCAD, reaching levels of detail that are not easy to do with P-CAD; you can then create a .DXF file and complete the design with P-CAD. The program translates the .DXF file into a P-CAD command macro that can create P-CAD sym-

bols and parts from the AutoCAD blocks; when you start P-CAD and execute the macro, you can watch the design being recreated. Because this version is also bidirectional, you can transfer P-CAD designs to AutoCAD or to any other CAE and documentation tool that can read the .DXF format. \$495 for new users; registered users of the unidi-

rectional PC-Trans version 1.0 can upgrade to version 2.0 at no charge.

CAD Solutions Inc, 2880 Zanker Rd, #103, San Jose, CA 95134. Phone (408) 943-1610.

Circle No 419

286 MULTITASKING

- *Operates under PC-DOS and OS/2*
- *Builds systems with >32,000 objects*

Smalltalk/V 286 is an object-oriented programming language for 80286- and 80386-based computers. It's an expanded version of Smalltalk/V for the IBM PC that allows multitasking and provides portability of applications from IBM PCs to Apple's Macintosh machines. You can build systems that have more than 32,000 objects and, because of the expanded-memory feature, objects can be larger than 64k bytes. An enhanced debugger shows currently executing methods and highlights the source-code statement as it is executing; it allows you to inspect and change all objects and correct errors without exiting the debugger, and lets you single-step through the program or run it at full speed. The windowing system and animation features operate twice as fast as in the original Smalltalk/V, according to the vendor. This version also works with EGA and VGA displays. Smalltalk/V 286, \$199.95; upgrades from the vendor's Smalltalk/V, \$75.

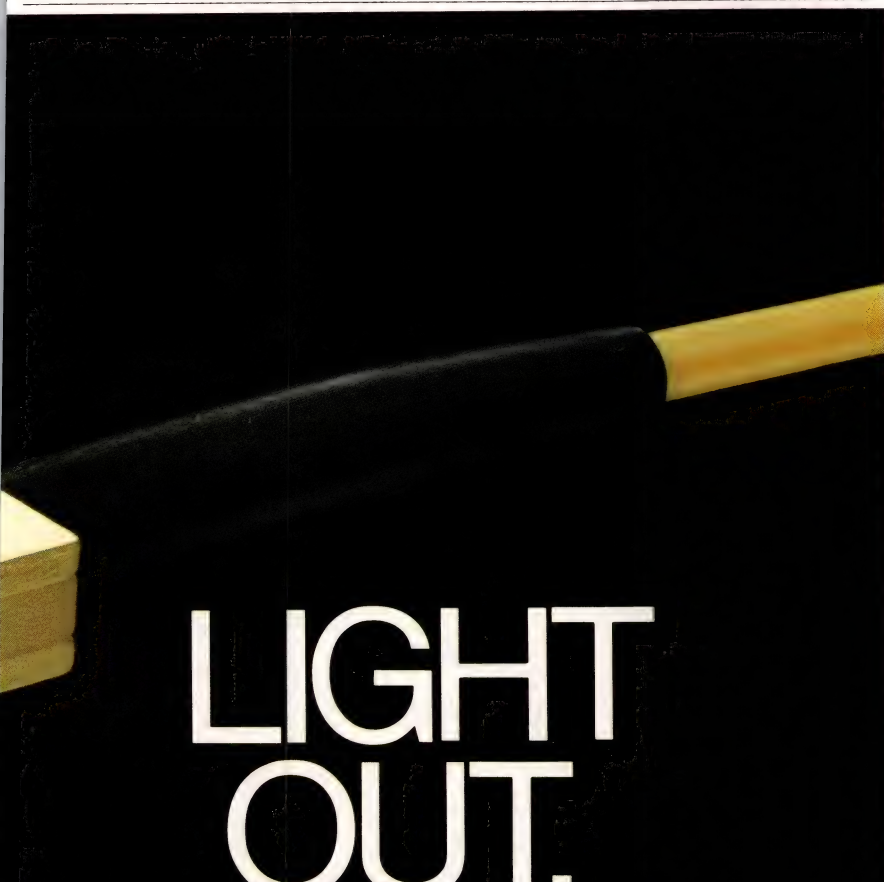
Digitalk Inc, 9841 Airport Blvd, Los Angeles, CA 90045. Phone (213) 645-1082.

Circle No 420

IEEE-488 MANAGER

- *Provides facilities for IEEE-488 network control*
- *Lets you use any number of IEEE-488 controllers*

GPIB Manager software allows a real-time multitasking and multi-



LIGHT OUT.

When it comes to high-speed laser diode packaging with true hermeticity, unmatched stability and stress resistance, TEK has it all.

Tektronix' family of electro-optic components provides unexcelled quality and proven performance that can give your products a competitive edge.

Now you can have it all—and on-time delivery too! Just dial 1-800-835-9433 and ask for Ext. 100. Your competitive edge... is just a phone call away.

Tektronix
COMMITTED TO EXCELLENCE

user VME Bus system to control an IEEE-488 network. You can incorporate any number of IEEE-488 controller boards into the system and can attach as many as 15 devices to each board, which is the maximum number permitted by the bus specification. The software package consists of GPIB Manager, GPIB device drivers, sample device descriptors, a system test program, and sample application programs. The test program is for use during development and installation; it can generate GPIB commands, and you can use it to test the GPIB bus communications and timing. GPIB Manager runs as a background process under the OS/9-68K operating system; it configures and initializes the IEEE-488 bus, after which application programs can request GPIB-related commands for execution by the GPIB driver. The software package runs on the vendor's CC-91 VME-GPIB interface board,

which performs standard IEEE-488 functions such as controller, listener, and talker. GPIB Manager software, \$750; CC-91 interface board, \$1675.

Compcontrol Inc., 15466 Los Gatos Blvd, Suite 109-365, Los Gatos, CA 95030. Phone (408) 356-3817. TWX 510-601-2895.

Circle No 421

SIMULATOR FOR MAC

- *Simulates analog circuits on Mac II*
- *Has same options as earlier versions*

PSpice is a simulator of analog electrical circuits that is widely used in its VAX, Sun, and IBM PC versions. The current release allows you to run the simulator on Apple's Macintosh II computer. Four options—Device Equations, Monte Carlo, Probe, and Parts Estimator—are

also available for the Macintosh II. Both Probe and Parts use Apple's standard graphics interface, so they work with all graphics devices for which Apple supplies device drivers. Pricing for the Macintosh versions: PSpice, \$1450; Device Equations, \$550; Monte Carlo, \$550; Probe, \$700; and Parts, \$700.

MicroSim Corp., 23175 La Cadena Dr, Laguna Hills, CA 92653. Phone (800) 826-8603; in CA, (714) 770-3022. TLX 265154.

Circle No 422

SCREEN EXTENDER

- *Enables images 16 times larger than the Macintosh screen*
- *Lets you view your image at reductions of 25%, 50%, or 75%*

The Stepping Out II graphics program for the Apple Macintosh can create a virtual screen as much as 16 times larger than the machine's ac-

FACT:

Parylene Coating Service Saves Manufacturing Costs

Off-site parylene coating service is your most effective and economical choice for conformal protection of circuit boards. Accomplished by practiced experts, the process eliminates concerns of contamination, pollution control and disposal. Labor, training, and costly space and capital equipment investments are also avoided.

Parylene is unmatched for conformal coating performance, meeting stringent Mil-I-46058C specifications, and preserving the repairability of costly circuits.

Nova Tran operates custom parylene coating centers in Wisconsin, Indiana, New Hampshire, California, Europe and Singapore, with application engineering services and fast turnaround. Call for more parylene facts.

Parylene...conformal coating without compromise.

NOVA TRAN CORPORATION.

100 DEPOSITION DRIVE
CLEAR LAKE, WISCONSIN 54005
715/263-2333/TELEX 29-0220
1-800-554-1697

UNION CARBIDE Subsidiary of Union Carbide Corporation
Copyright ©1988 Nova Tran Corp.

```

graph LR
    Customer[Customer] --> Preparation[Preparation]
    Preparation --> Coating[Coating]
    Coating --> Inspection[Inspection]
    Inspection --> Customer
    
```

Maximum coating performance with minimal labor and equipment investment.

MICRO-LOGIC II.™

The CAE tool with a 10,000-gate digital simulator for your PC.



Spectrum Software's MICRO-LOGIC II® puts you on top of the most complex logic design problems. With a powerful total capacity of 10,000 gates, MICRO-LOGIC II helps engineers tackle tough design and simulation problems right at their PCs.

MICRO-LOGIC II, which is based on our original MICRO-LOGIC software, is a field-proven, second-generation program. It has a high-speed event-driven simulator which is significantly faster than the earlier version.

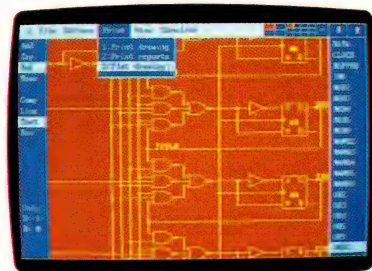


Timing Simulator



Shape Editor

- Built-in shape editor
- Multiple delay models
- Printer and plotter hard copy



Schematic Editor

A 200-type library of standard parts is at your fingertips. And for a new high in flexibility, a built-in shape editor lets you create unique or custom shapes.

MICRO-LOGIC II is available for the IBM® PC. It is CGA, EGA, and Hercules® compatible and costs only \$895 complete. An evaluation version is available for \$100. Call or write today for our free brochure and demo disk. We'd like to put you in touch with a top digital solution.

- Total capacity of 10,000 gates
- Integrated schematic editor
- Fast assembly language routines
- Standard parts library of 200 types
- Event-driven timing simulator

The program provides you with a top-notch interactive drawing and analysis environment. You can create logic diagrams of up to 64 pages with ease. The software features a sophisticated schematic editor with pan and zoom capabilities.

spectrum

1021 S. Wolfe Road, Dept. E
Sunnyvale, CA 94087
(408) 738-4387

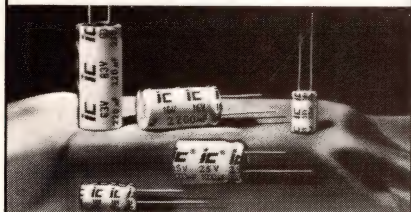
MICRO-LOGIC II is a registered trademark of Spectrum Software.

Hercules is a registered trademark of Hercules Computer Technology

IBM is a registered trademark of International Business Machines, Inc.

ic[®] RZS

High Frequency Electrolytic Capacitors



Proven Reliability

... 100% Burn-In Tested

- 22 Mfd. to 2,200 Mfd.
- 6.3 WVDC to 63 WVDC
- -55°C to +105°C
- ±20% Std. (±10% Opt.)
- High Ripple @ 100KHz
- Solvent Tolerant Seal Std.
- Low ESR, Low ESL
- Tape & Reel Available

ic[®] TECH TIPS

ic type RZS is designed for a wide range of applications including high frequency filtering, high temperature ambients (up to +105°C), sinusoidal and nonsinusoidal waveforms, high ripple currents, and extremely low temperature (-55°C) environmental applications. Type RZS offers the high reliability desired in automotive, telecommunications, industrial process control, medical instrumentation and power supply applications. Featuring excellent electrical characteristics across the entire temperature and frequency range including very low impedance, type RZS is designed for long life operation. The low ESL design provides high frequency performance beyond 100KHz. The low ESR characteristics across the temperature and frequency range yield reliable cool operation at high ripple current levels. The solvent tolerant end seal design is perfect for use with many modern circuit board cleaning systems. Type RZS gives the designer a wide range of characteristics to choose from in a single series.

©1987 ILLINOIS CAPACITOR, INC.

The source for Quality.
Performance and Delivery.

ic[®]
ILLINOIS CAPACITOR, INC.
3757 West Touhy Avenue
Lincolnwood, Illinois 60465
(312) 675-1760

CAE & SOFTWARE DEVELOPMENT TOOLS

tual screen. Whenever the cursor hits the edge of the actual screen, the view of the image scrolls up, down, left, or right. You can use the program with CAE/CAD and word-processing applications programs to create large text and images, and then either work on a small scale or use a reduction to obtain an overall view of the drawing. The program is compatible with the Macintosh II and with Multifinder. \$95.

Berkeley System Design Inc.,
1708 Shattuck Ave, Berkeley, CA
94709. Phone (415) 540-5536.

Circle No 423

WORM FOR UNIX

- Makes an optical-storage drive emulate a magnetic drive
- Works with three 12-in. and two 5¼-in. drive models

Dorofile software lets you integrate a worm (write once/read many) optical drive into a Unix system. The package creates a new file system that causes the CPU to perceive the optical drive as a magnetic hard-disk drive, yet grants access to optical storage. The software works with three 12-in. drives (the LD-1200 from Control Data/Phillips, Optimem's Model 1000, and Gigadisc's DG1001) and two 5.25-in. drives (Optotech's Model 5984 and Maxtor's Model 800S). Optical disks provide 2G bytes of storage apiece and feature a life expectancy in excess of 10 years. You access the optical disk in the same manner as you would access disk or tape drives—via Unix-like commands and calls. You can connect the disk drive and controller directly to processors that already have SCSI interfaces, or you can add external SCSI controllers to systems that don't have them. The package comes on ¼-in. tape and includes a device driver. \$3000 (50).

Zetaco, 6850 Shady Oak Rd,
Eden Prairie, MN 55344. Phone
(612) 941-9480. TLX 290975.

Circle No 424

VAX GRAPHICS

- Lets you create logic diagrams and other line art
- Provides a menu mode for novices

You use the Draw interactive graphics program to create, revise, and display line drawings on a VAX workstation. It's suitable for logic diagrams, training aids, mechanical drawings, floor plans, maps, and other applications. The program's menu mode provides clear guidance and extensive on-line help for the novice. When you're familiar with the program, you can switch to the command mode, or to the tablet mode, which provides maximum precision and allows you to digitize line art. You can direct the output to a wide range of devices, such as pen plotters, laser printers, ink-jet plotters, and PostScript-compatible devices. The package comes with a library of more than 300 symbols, and you can build your own library of specialized symbols for your application. The program runs on VAX/VMS systems that have a VT-240, VT-340, or Tektronix display-list graphics terminal or its equivalent. From \$3500.

Precision Visuals, 6260 Lookout
Rd, Boulder, CO 80301. Phone (303)
530-9000.

Circle No 425

LANGUAGE

- Provides the Simula programming language on PCs
- Has cross-compilation support between operating systems

The PC-Simula version of the Simula object-oriented programming language runs on IBM PCs. The vendor offers the language configured to run under the MS-DOS, Xenix, or OS/2 operating systems. The MS-DOS version, tested on an IBM PC/XT and PC/AT, requires 640k bytes of RAM to run. The vendor tested the Xenix version under Santa Cruz Operation's Xenix



Only Pioneer Power Supplies Deliver .99 Power Factor

That's the typical power factor on Pioneer supplies with the power factor option. That means only Pioneer can give you 1000 watts of DC power from a standard UL 115 VAC, 15 amp wall plug. That's 300 more watts of usable power for system peripherals and accessories.

115/230 volt input strapping is eliminated. You can operate over a continuous range from 90-264 VAC.

You'll also get the added benefits of improved hold-up performance, reduced line harmonics between 10 and 150 kHz, and no AC line frequency sensitivity.

We offer the broadest high power line in the industry. From 250 to 2000 watts, single or multiple output, AC/DC or DC/DC. Standard units are certified to UL, CSA and IEC safety to Class I SELV levels and meet VDE and FCC conducted and radiated EMI specs.

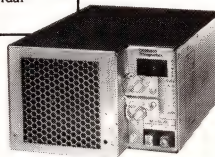
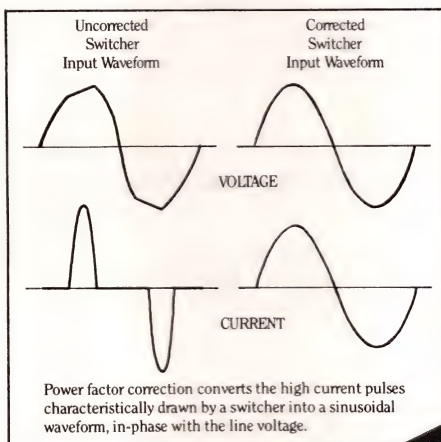
With all options you might need, including built-in Single-Channel Battery Backup, Single-Wire Load Sharing, "connectorized" modules for hot-changing, or any of three dozen more.

No matter how tough your specs, chances are excellent that Pioneer has built one like it. Why not? We've shipped over 300,000 high power switchers. Worldwide.

And reliability? All supplies are 100% tested and given a 48-hour, full-power burn-in. That's how we achieve MTBFs up to 250,000 hrs.

So if you'd like to turn up the output power on your next supply by over 30%, call us at 800-233-1745. In Calif., 800-848-1745. Or write 1745 Berkeley Street, Santa

Monica, CA 90404.
FAX: (213) 453-3929.
We're the only ones with .99.



**Pioneer
Magnetics**

New Low Cost MMIC Amps: DC to 1.8 GHz bandwidths, Power to 20 dBm, and priced as low as 75¢ each.

Talk about a great deal. NEC's tiny new amps are available in wide bandwidths, a variety of packages, and they're designed to help eliminate your biasing and grounding problems.

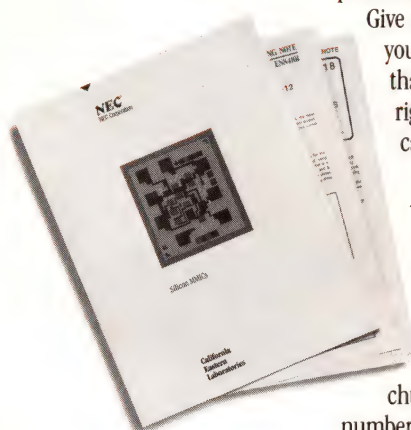
And at 75¢ each in quantities of 500 you get *both* NEC quality *and* a better price than the so-called "low cost" amps.

Give us a call today. We'll work with you engineer-to-engineer to see that you get the right amps at the right price. And in most cases, we can ship them right off the shelf.

NEC technology and quality—and CEL service. It's a powerful combination. Put it to work for you.

FREE DATA FOR DESIGNERS

For app notes and a full line Si MMIC specifications brochure, call, write or circle the number below.



NEC®

California Eastern Laboratories

3260 Jay Street, Santa Clara, CA 95054 (408) 988-3500
Western (408) 988-3500 Eastern (301) 667-1310
Canada (613) 726-0626
Europe NEC Electronics GmbH 0211/650301

© 1987 California Eastern Laboratories

CIRCLE NO 48

DID YOU KNOW?

EDN serves
electronic engineers and
engineering managers in more than
100 countries worldwide.

EDN

CAE & SOFTWARE

System V and under Microsoft Xenix, and the OS/2 version, on an IBM PC/AT running Microsoft OS/2; you need a computer with 1.5M to 3M bytes of RAM to run either version. All versions call for a computer with a math coprocessor and a hard disk. You can order cross compilers to transfer programs between MS-DOS and Xenix and between MS-DOS and OS/2. Single-user licenses for the various versions, 10,000 to 15,000 Norwegian Kroner; cross compilers, 20,000 Norwegian Kroner.

Simula as, Box 4403, Torshov, 0402 Oslo 4, Norway. Phone (2) 156710.

Circle No 426

TURBO C DEBUGGER

- Provides breakpoints and single-stepping
- Switches between program and debugger screens

The A-COM debugger is a full-screen, source-level debugger for use with Borland International's (Scotts Valley, CA) Turbo C programming tools. The debugger is menu driven: You select the most commonly used functions via function keys. You can set breakpoints to stop the program you're testing when it reaches specified statements. In addition, you can make your program run until it reaches a breakpoint, or you can execute it statement by statement; in the latter case, you have the option of skipping over the functions called by a statement, or of stepping through the functions. You can also toggle-switch the display between the debug screen, which shows you the statements as they run and variables as they change, and the program screen, which you normally see while running the program. \$24.95.

A-Com, 13511 NE 129th Pl, Kirkland, WA 98034. Phone (206) 821-2192.

Circle No 427

Plessey Microsystems puts the 68030 in its proper place

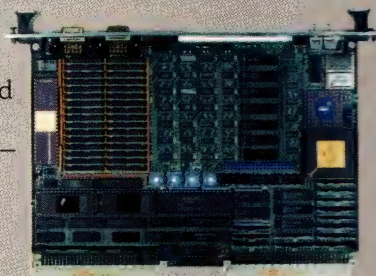
...and doubles your VME processing power!



If you've been yearning to double the processing power and throughput of your VME system, the wait is over. Once again, Plessey Microsystems has taken the lead... with our new 68030-based PME 68-32 VME Single Board Computer. It puts all the power of the 68030 into the industry's fastest, most powerful and versatile VMEbus processor board. And we're not talking about a board that's under development. The PME 68-32 is here... right now!

Doubling Your Processing Power With...

- 68030 processor
- Optional 68882 floating point co-processor
- 4 Mbytes true dual-ported DRAM
- Cache burst fill capability—zero wait states
- Two high-speed serial ports—up to 1 Mbit/sec.
- Remote reset
- Mailbox interrupts
- Flexible dual-ported address mapping
- Complete VMEbus system control functions



Plus the Unique PEX Interface...

Our unique on-board PEX (Plessey Extension bus) Interface allows you to easily meet even highly specialized application requirements. You can put the functionality you choose onto the 68-32 because it puts so many interface possibilities at your disposal, including SCSI and others like parallel I/O, Ethernet*, floppy disk, additional serial I/O...and more!

...And Smooth, Easy Upgrade Paths...

The PME 68-32 is part of a complete family of Plessey Microsystems processor boards incorporating the 68000 series of processors. That means minimal—or even zero—software changes from one product to the next. If you're using our 68020-based processors now, you can easily upgrade to the PME 68-32... now!

...For Ultimate VME Strength.

With our 68030-based processors, Plessey continues to extend its lead in VME technology. And not just processors. We've got a host of new VME memory boards, I/O and controller boards, and systems and software. Call or write for details and make Plessey's ultimate VME strength your system's greatest strength.

*® Xerox Corp.

UK Water Lane, Towcester, Northants, NN12 7JN (0327) 50312
USA One Blue Hill Plaza, Pearl River, NY 10965 (914) 735-4661
France 7-9 Rue Denis Papin, 78190 Trappes (1) 30. 51.49.52
Germany Bahnhofstraße 38, 6090 Rüsselsheim (061 42) 6 80 04



PLESSEY MICROSYSTEMS

PLESSEY and the Plessey symbol are registered trademarks of The Plessey Company plc.

FFT LIBRARY

- >300 data array sizes
- Math coprocessor speeds calculations

Two-Dimensional Prime Factor FFT is a subroutine library of fast Fourier transforms. Its prime-factor algorithm allows you a choice of more than 300 data-array sizes and,

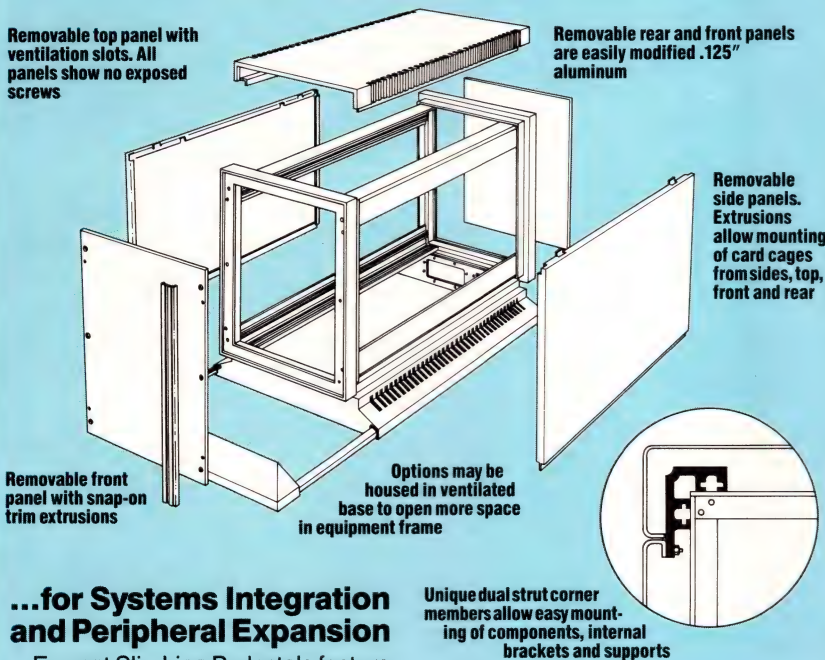
according to the vendor, is both faster and more accurate than power-of-2 algorithms. On an 80386-based PC, you can perform frequency analysis on data sets as small as 2x2 data points and as large as 65,520x65,520 data points. Furthermore, the vendor claims that this is the first PC-based FFT product to calculate rectangular FFTs,

so that you can match the FFT calculation to an experimental array whose width is not equal to its length. You can call the routines from any high-level language; the manual provides interface examples for Turbo Pascal, Microsoft C, Lattice C, QuickBasic, Microsoft Fortran, Lahey Fortran-77, and assembly language. \$159.

Alligator Technologies, Box 9706, Fountain Valley, CA 92708. Phone (714) 850-9984.

Circle No 428

SlimLine Pedestals Provide Ultimate Flexibility...



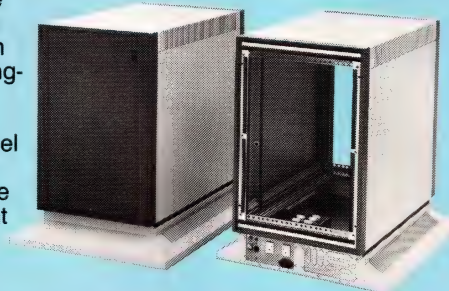
...for Systems Integration and Peripheral Expansion

Everest SlimLine Pedestals feature panels that are quickly and easily removable from the front, rear, sides and top to give you total flexibility in installing and servicing your rack mounted systems and peripherals.

Compatible in appearance with the Everest Econoline and Ultraline series, these ruggedized pedestals are available in 24-inch and 30-inch deep versions. Both fit under or alongside most workstations and accept deep card cages from the side—leaving more space in the front panel for disk drives and other devices.

Available in a variety of colors, the SlimLine design shows no apparent

exposed screws and complements any office environment. Everest offers options like casters, RFI/EMI shielding, fan/filter trays, AC power controllers and more, and is open to your needs for custom and modified versions.



Everest Electronic Equipment

1800-G MacLeod Drive, Lawrenceville, GA 30243, 404-995-8688
2100 E. Orangewood Ave., Anaheim, CA 92806, 714-634-2200.

Please See Us At Electro Show '88 Booths 2524 & 2526

STRESS ANALYSIS

- For electronic and mechanical systems
- Includes import and export facilities

Reliability Prediction Program (RPP) 3.1 provides stress analysis of parts in accordance with MIL-HDBK-217. This version has more than 40 new features, including quality-level default values for all parts, junction-temperature default values for ICs, and voltage default values for transistors and diodes. The program now lets you make full use of the MS-DOS path features, and you can also transfer data freely between the program and ASCII files or dBASE III-compatible files. In addition, this version can exploit a math coprocessor (if your system has one) to increase calculation speed. Optional enhancements allow parts cataloguing, global data changes, batch input, and stress analysis in accordance with MIL-HDBK-1547. To run the program, you'll need an IBM PC/XT or PC/AT that has at least 512k bytes of RAM and a hard-disk drive. RPP 3.1, \$1700; options, \$500 each.

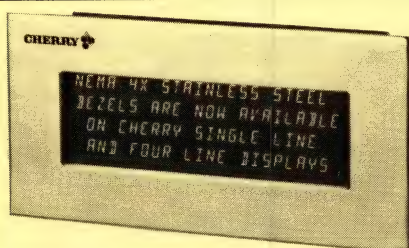
Powertronic Systems Inc., Box 29109, New Orleans, LA 70189. Phone (504) 254-0383.

Circle No 429

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number
for additional information from manufacturers.



4 Line x 24 Character INTELLIGENT Display System

Instant information on problems, machine or process status as it happens. . . or is about to happen. In plain English. NEMA 4X SS bezel.

List price only **\$1160.00**

(Also available, NEMA 12 bezel at \$960.00)



CHERRY ELECTRICAL PRODUCTS
3600 Sunset Avenue • Waukegan, IL 60087 • 312-360-3500 • FAX: 312-360-3566

CIRCLE NO 325



"The Best 8051 Emulator"



NEW
Program
Performance
Analyzer

8051

PC based emulators for the 8051 family

(8051, 8751, 8052, 8752, 8031, 8032, 8344, 80C452, 80C152, 80535, 80C451)

- PC plug in boards
- Command driven User Interface with static windows
- 16 MHz real time emulation
- 128K emulation memory
- 48 bit wide, 16K deep trace buffer with loop counter
- Program performance analyzer
- Powerful Macros with IF-ELSE, REPEAT, WHILE structures
- Single step in PL/M-51 and C-51
- Symbolic debugging with in-line assembler and disassembler
- No external boxes
- Execution time counter
- Trace can be viewed during emulation!

PRICES: 32K Emulator for 8031 \$1790, 4K Trace \$1495

CALL OR WRITE FOR FREE DEMO DISK!

Ask about our demo VIDEO!

NOHAU

CORPORATION

51 E. Campbell Ave. #107E, Campbell, CA 95008 (408) 866-1820

CIRCLE NO 326

the HUSKY™

EPROM
PLD
MICRO
GANG
SET



PC based PROGRAMMER

\$599.00*

*modules not included.

From A Name You Can Trust

LOGICAL DEVICES, INC.

1201 N.W. 65th Place, Ft. Lauderdale, FL 33309

1-800-331-7766 (305) 974-0967

Telex 383142 Fax (305) 974-8531

CIRCLE NO 329

EMUL51-PC IN EUROPE

SWEDEN, NORWAY, FINLAND

Nohau Elektronik AB tel. 040 92 24 25

GERMANY

iSystem GmbH tel. 08131 1687

FRANCE

Emulations s.a.r.l. tel. 01 69 412 801

DENMARK

Tage Olsen A/S tel. 02 65 81 11

SWITZERLAND

thau Computer AG tel. 01 740 41 05

PORTUGAL

Fatronica lda tel. 01 83 56 70

We are currently seeking representatives in:

Great Britain, Italy, Spain, Holland,
Belgium and Austria

CIRCLE NO 327

DSP ASAP \$1,995

Drive your DSP design to market as fast as possible with our 320C25 in-circuit emulator.

The ICE PAK features real time emulation to 40 MHz, 16K words (35ns) program overlay memory, user definable break handler routine, single step trace, disassembler, and RS-232 communications for fast downloading of programs and data.

Options include 64K word non-volatile memory upgrade, cross assembler and communications software for PC or Macintosh.

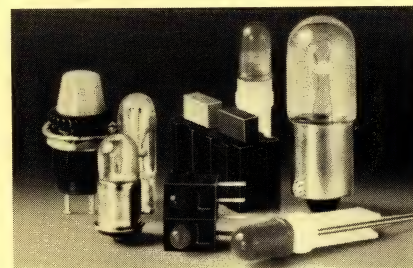
Inquire about our 320C10 ICE PAK.
1301 Denton Drive,
Suite 204
Carrollton,
TX 75006
(214) 446-9906

MEMOCOM
DEVELOPMENT
TOOLS



CIRCLE NO 328

NEW WORLD-CLASS VCH LINE REDEFINES INDUSTRY STANDARDS



We set the industry standards 20 years ago, when we were Chicago Miniature. Now we're ready to do it again as VCH, with this full line of incandescent lamps, indicators, LED displays, lamps, light bars and circuit board indicators. Plus expert service in this country in a few hours.

vch
INTERNATIONAL

CHICAGO MINIATURE BRAND

Buffalo Grove, IL 312/459-3400

CIRCLE NO 330

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

SMART CARD EXTENDER

EASY ON \$195⁰⁰ — PC/XT \$225⁰⁰ — AT

A smart card extender for PC/XT/AT and compatibles

- Allows card insertion and extraction without power on/off cycles
- Saves time by eliminating DOS re-boots
- Reduces wear and tear on hard disk drives
- Extends host interface for hardware and software development and test
- A single switch controls the connection of all signals to and from the computer bus
- Patent pending



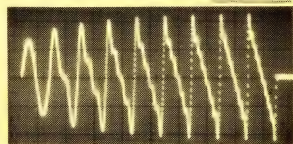
30 DAY NO RISK EVALUATION
APPLIED DATA SYSTEMS

9811 Mallard Dr. Suite 203
Laurel, MD 20708

For more information call 800-541-2003

CIRCLE NO 331

WAVEFORM SYNTHESIZER



- For IBM-PC/XT/AT and compatibles
- Generates user-definable signal
- Up to 2000 points per envelope



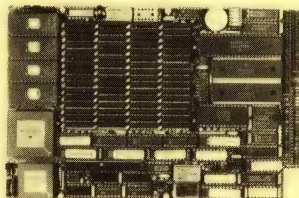
\$795.00

478 E. Exchange St. Akron OH 44304
(216) 434-3154 TLX: 5101012726
1-800-553-1170

CIRCLE NO 334

68020 SBC

Only \$1298.50 (Qty. 100)



- 12.5 MHz 68020
- Centronics' PLL Port
- SASI/SCSI Port
- 256 KB EPROM (max.)
- I/O Expansion Port
- 8.8" x 5.75"
- 1 MByte DRAM
- 4 RS-232 Serial Ports
- TOD Clock w/battery
- 3.5/5.25" Floppy Controller
- ROM Monitor/Diagnostics
- Mounts on a 5.25" Drive

Optional: 2 MByte RAM, 4 MByte RAM w/MMU, 16.67 or 20 MHz versions, 68881/2 FPC, additional serial and parallel ports; ARCNET LAN, Color Graphics, UniFLEX or OS-9/68020 DOS, C, BASIC, PASCAL, FORTRAN, Assembler, Spreadsheet, Data Base Management.

Also Available: 68030 version w/4 Mbyte RAM.

GMX INC. 1337 West 37th Place, Chicago, IL 60609
Ph. (312) 927-5510 TWX 910-221-4055 FAX (312) 927-7352
State-of-the-Art Computers Since 1975

CIRCLE NO 337

Digital Control Intro \$200 Digital Filter Tutor \$450 Kalman Filter Tutor \$925

Practical hands-on training courses that run on the IBM PC. Ideal alternative to text books, seminars, and university courses. FREE demo disk available.

Engineering Tutorial Software
22338 Lull Street
Canoga Park, CA 91304
(818) 716-0816

CIRCLE NO 332

Not Copy Protected

DC/DESIGN™

Complete PCB Design Package **\$695**

Includes Draftsman-EE™ and DC/Check +™, each sold separately for \$395. Low-cost options include:

DC/Autorouter I™ \$795
DC/Convert™ (Format Converter) \$195

DC/Design for IBM PCs and compatibles features easy-to-use menus for Schematic Capture; Net List, BOM, and Rat's Nest generation; interactive parts placement and routing; design rule checking; and complete, professional documentation.

NEW HIGH-POWERED SYSTEMS™

Includes High-Performance, Surface Mount Technology, 32" x 32" board size and 64 layer support. *Copy Protected

DC/DESIGN II™ \$1,195
DC/810 II™ \$1,995
DC/CAD II™ \$2,995
DC/Hi-Res™ (optional) \$495

CALL TODAY TO ORDER!
UNCONDITIONAL 30-DAY
MONEY-BACK GUARANTEE

**DESIGN
COMPUTATION**

Route 33 Sherman Square, Farmingdale, NJ 07727
(201) 938-6661

CIRCLE NO 335

NO WAITING FOR COMPLETE, LOW PRICED, CHIP COMPONENT KITS

CC-1 Capacitor Kit contains 365 pieces, 5 ea. of every 10% value from 1pF to .33µF. CR-1 Resistor Kit contains 1540 pieces; 10 ea. of every 5% value from 100 to 10 megΩ. Sizes are 0805 and 1206. Each kit is ONLY \$49.95 and available for immediate One Day Delivery!

Order by toll-free phone, FAX, or mail. We accept VISA, MC, AMEX, COD orders, or company PO's with approved credit. Call for free detailed brochure.



COMMUNICATIONS SPECIALISTS, INC.
426 West Taft Avenue • Orange, CA 92665-4296
Local (714) 998-3021 • FAX (714) 974-3420

Entire U.S.A. 1-800-854-0547

CIRCLE NO 333

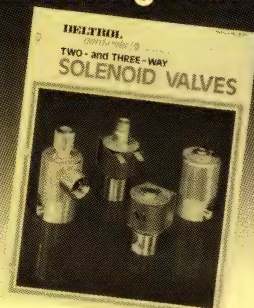
Join Forces

Combine your larger ads with EDN Product Mart ads for a total marketing program.

EDN Product Mart

CIRCLE NO 336

Solenoid Valve Engineering Catalog



Send for the latest 40-page Solenoid Valve catalog from Deltrol. Packed with useful information on full range of 2 & 3-way solenoid valves for most liquids and gases • Direct acting normally open and normally closed models with plastic-molded coils, brass or stainless bodies.

DELTRON
controls

4331 DIVISION OF DELTRON CORP.

CIRCLE NO 339

2745 S. 19th St.
Milwaukee, WI 53215
Phone 414/671-6800
Telex 2-6871

UNIVERSAL E(E)PROM PROGRAMMER \$495 (Kits from \$165)

- No personality modules; Menu driven device selection.
- Built-in Eraser/Timer option (\$50); Conductive foam pad.
- Direct technical support; Full 1 year warranty.
- Stand alone duplication & verify (27XX parts).
- Quick pulse algorithm (27256 under 60 sec).
- 27xx to 1 Mbit; 25xx; 68xx; CMOS; EEPROMS.
- 8741, -2, -4, -8, -8H, -9, -9H, -51, -C51, -52, -55, 9761 & more.
- IBM-PC, Apple, CPM or Unix driver; Autobaud RS232.
- Offset/split Hex, Binary, Intel & Motorola 8,16,32 bit.
- Manual with complete schematics.

VISA MC AMEX Call today for datasheets!!

B&C MICROSYSTEMS

355 WEST OLIVE AVE. SUNNYVALE, CA 94086
PH: (408) 730-5511 FAX: (408) 730-5521 TELEX: 984185

CIRCLE NO 338

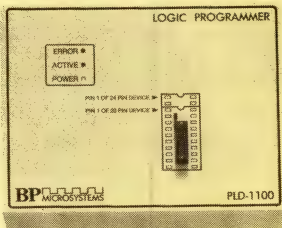
To advertise in Product Mart, call Joanne Dorian, 212/463-6415

UNIVERSAL LOGIC PROGRAMMER

- PROGRAMS, READS, DUPLICATES, TESTS AND SECURES HUNDREDS OF 20- AND 24-PIN DEVICES

- 23 UNIVERSAL PIN DRIVERS WITH INDEPENDENT DAC, ADC & SLEW FUNCTIONS
- PROGRAM ALMOST ANY LOGIC DEVICE
- MENU DRIVEN OPERATION IS EASY TO LEARN AND QUICK TO OPERATE

- CONNECTS TO ANY IBM COMPATIBLE VIA PARALLEL PRINTER PORT
- EDITS FUSE DATA & TEST VECTORS WITH FULL SCREEN EDITOR
- TESTS WITH VECTORS & SECURES AFTER PROGRAMMING
- SUPPORTS ALL POPULAR PLD DEVELOPMENT SOFTWARE
- ONLINE HELP FUNCTION
- SELF CALIBRATING
- JEDIC FILE INPUT & OUTPUT
- 30 DAY MONEY BACK GUARANTEE
- EPROM PROGRAMMERS ALSO



CALL FOR FREE DEMO DISK OR INFO 800/225-2102

BP MICROSYSTEMS

10681 HADDINGTON #190 HOUSTON, TX 77043
713/461-9430 TLX: 1561477 FAX: 713/461-7413

CIRCLE NO 340

ROMX-2 Eprom Emulator

- Emulates 2716-27256 Eproms.
- Fast 19,200 Bps Transfer Rate.
- Menu Driven Eprom Selection.
- Non-Volatile Memory.
- Pays For Itself With First Project.
- Software Included Free!

GTEK INC.

Development Hardware & Software
P. O. Box 2310

Bay St. Louis, MS 39521-2310
Order Toll Free 1-800-255-GTEK (4835)
Fax: 1-601-467-0935 Telex 315814 (GTEK UD)
MS & Technical Support 1-601-467-8048

CIRCLE NO 341



GANG/SET (E)EPROM MULTIPROGRAMMERS™

Model 135-E: \$995⁰⁰

- BYTEK's 135 is a SET Programmer, GANG Duplicator, & UNIVERSAL Device Programmer.
- Programs virtually all 24, 28, & 32-pin (E)EPROMs.
- RAM expandable to 2MegaByte.
- Optional support for 40-pin EPROMs, Bipolar PROMs, 40-pin Micros, & (E)PLD/GAL/FPLA Devices.
- 18-Month FREE WARRANTY and also 12-Month FREE DEVICE UPDATES.

1-800-523-1565

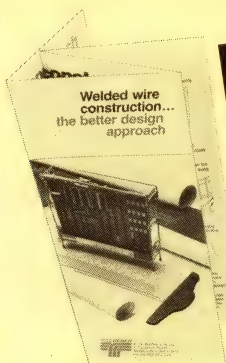
In Florida: 1-407-994-3520

BYTEK

BYTEK Corporation
1021 S. Rogers Cir., Boca Raton, FL 33487
FAX: (407) 994-3615 Telex: 4998369 BYTEK

* [U.S. Prices only]

CIRCLE NO 342

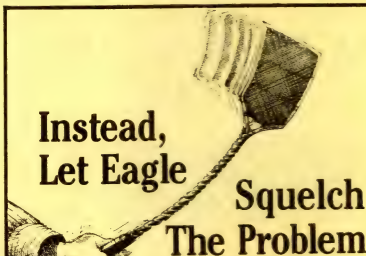


FREE Design Guide to cut costs on chassis and enclosures

Our new Engineering Design Guide is loaded with tips and design ideas to reduce chassis and enclosure costs and improve performance using steel wire construction. For a free copy write:

TITCHENER E.H. Titchener, 28 Titchener Place, P.O. Box 1706, Binghamton, NY 13902
Phone 607-772-1161
FAX 607-771-0264

CIRCLE NO 343



Are you trying to swat down your own EMI problems? Eagle is dedicated to providing dependable magnetic shielding solutions with the most original design engineering available. We save you time. We save you money.

Call Eagle at (317) 297-1030 for problem design assistance, or write for FREE engineering design information packet #03 and let us handle the squelching.



Eagle Magnetic Company, Inc. • P.O. Box 24283
Indianapolis, Indiana 46224 • (317) 297-1030 • FAX 317-299-1323

CIRCLE NO 344



Project: PCB +, now with VGR

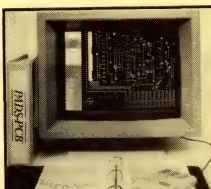
The best bargain in PCB design software just got better. **Project: PCB**, with symbol/parts editors, schematic capture, board layout, interactive routing and auto-routing, is now available with **VGR**: a Variable Grid Router. **Project: PCB +** offers user-selectable routing grids, trace widths and via diameters. VGR can also access extra memory for larger boards.

Project PCB + is only \$1500.00 (EGA-compatible version).

Demo systems available.

DASOFT Design Systems, Inc.
1827-B Fifth Street, Berkeley, CA 94710
(415)486-0822

CIRCLE NO 345



PADS PCB
\$975.00

USA & CANADA ONLY

Everything you've always wanted in a CAD Engineering workstation and affordable!

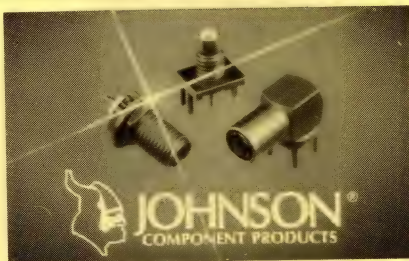
- Inputs from FutureNet™, Orcad™, Schema™
- 1 Mil database, 32 x 32", 30 Layers
- Routing Grids: 1, 5, 10, 20, 25 & 50 Mils
- 1, 2 & 3 Tracks between IC Pads
- Interactive and Automatic Placement and Routing*
- XT, AT & 386 (and compatibles)
- Full Air Gap & Connectivity Checking
- 200 IC Capability (400 IC optional)
- Full SMD & Analog Support
- Evaluation Kit \$50.00: contains actual software on multiple disks, and detailed manuals * optional

Outside MA 1-800-255-7814
Inside MA 1-617-486-9521

CAD Software, Inc.

P.O. Box 1142, Littleton, Massachusetts 01460

CIRCLE NO 346



MIL QUALITY / LOW PRICE CONNECTORS

Our JCM connectors deliver the same MIL-SPEC quality as SMA-types, without charging you for expensive materials and military paperwork. The JCM line offers commercial versions of SMA/SMB/SMC RF plugs, jacks, adapters, test jacks, cable sets and PC-mount cable terminations in popular sizes and types. Get MIL-C-39012 performance without the MIL price.

Call 800/247-8343 for a free JCM catalog.
(In MN: 507/835-6222)

EF JOHNSON COMPONENTS

CIRCLE NO 347

Worried About EMI/RFI? USE ELECTRODAG® SHIELDING COATINGS

- Air or Force Dry Formulations.
- UL Recognized for Good Adhesion.
- Line Proven, Easy Application.
- Stable Low Electrical Resistance.
- Choice of Copper, Nickel or Low Cost Silver Conductive Fillers.
- Prototype Service Available.

Acheson

1600 Washington Ave., Port Huron, MI 48060

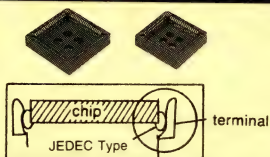
TOLL FREE **1-800-255-1908**

CIRCLE NO 348

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

TTC Low-Profile Plastic Leaded Chip Carrier Socket

Reliable products & Reasonable price!



Special design makes the contact stably.
To be a connector manufacturer, we specialize in the following items:

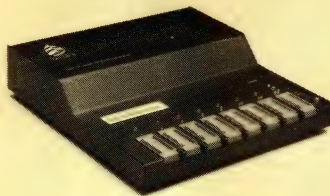
1. PLCCS-44P, 68P, 84P
2. IC Socket (Dual in line)- 6P, 8P, 14P, 16P, 18P, 20P, 24P, 28P, 40P, 34P (4Rows)
3. Slot (Edge Card connector)- 36P, 50P, 62P, 80P, 86P, 98P, 100P.
4. shunt (Mini Jumper)
5. Pin Header: 2P — 40P (Single Row or Double Rows, Straight or Right Angle)

((OEMs are wellcome))

TTC Shih Hsin Precision Corp.

No. 2, Lane 75, San Jun Street, Shu-Lin Town, Taipei, Taiwan, R.O.C. Tel: 886-2-6894655, 689-4656
Fax: 886-2-6894657 Telex: 33210 TTCCO

CIRCLE NO 349



SAILOR PROGRAMMERS: NO WAITING FOR DOWNLOAD!

Directly controlled by IBM PC/XT/AT/PS2. Save you hours of download time each week. Virtual memory feature — requires no RAM modules even for megabit devices. Industrial quality.

Sailor-PAL: Supports PLDs from over 10 mfrs; Bipolar, CMOS, EPLD, GAL, PEEL, and ECL. S/W driven, universal electronics.

Sailor-2,-8: 2 and 8 sockets, supports EPROMs up to 1 megabit, set and gang functions.

ADVIN SYSTEMS, INC.

1050 East Duane
Sunnyvale, CA 94086
408-984-8600 TLX 5106005624

CIRCLE NO 350

E & H Field Probes

\$495



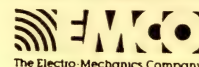
EDN "Readers Choice" (6/25/87)

Makes finding E & H Field emissions easy!

Use with any o-scope or spectrum analyzer. Set includes three H and two E field probes, extension handle, case, documentation, two year warranty. Pre-amp with battery charger, optional. Call, write to order or for brochure.

1-800-253-3761

PO Box 1546 Austin, TX 78767



CIRCLE NO 751



CROSS-16 META ASSEMBLER

- Table based 8/16 bit cross-assembler.
- Uses manufacturer's assembly mnemonics.
- Tables & Example Source files are included for ALL of the following processor families:

1802	3870	64180	6502
65816	6801	6805	6809
6811	68000	7000	8048
8051	8085	8086	8096
COP800	SUPER8	Z8	Z80

- Users may modify or create new tables for additional processors.
- Produces listing, symbol table, and 8/16 bit binary, Intel and Motorola hexcode.
- 5" DSDD for PC/MS-DOS 2.0 or greater.
\$99.95 US \$139.95 CDN
- Portable C sourcecode is available.

Worldwide shipping (AIRMAIL) & handling included. Credit Card orders (\$139.95 CDN) please specify: Card number, name on card and expiry date.



Universal Cross-Assemblers

P.O. Box 384, Bedford, N.S.
Canada B4A 2X3

CIRCLE NO 752

72 DIGITAL I/O FOR PS/2



MODELS 50, 60, 80

- Parallel Expansion
- 72 I/O Lines
- Address Selectable
1-800-553-1170



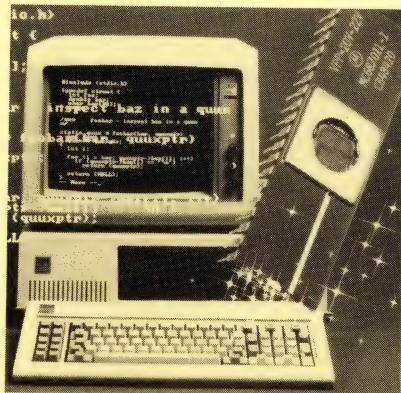
478 E. Exchange St., Akron, OH 44304
TEL: (216) 434-3154 FAX: (216) 434-1409
TLX: 5101012726

CIRCLE NO 753

Small Space Advertising For Big Results

EDN Product Mart

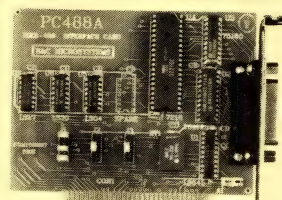
CIRCLE NO 754



6800-Family Development Software

Combine our software and your editor for a powerful development system. Our C-Compilers feature a complete implementation (excluding bit fields) of the language as described by Kernigan & Ritchie and yields 30-70% shorter code than other compilers. Our Motorola-compatible Assemblers feature macros and conditional assembly. Linker and Terminal Emulator are included. **Wintek Corporation**, 1801 South St., Lafayette, IN 47904. (800) 742-6809 or (317) 742-8428.

CIRCLE NO 755



PC488 \$145

LOW COST PC/XT/AT INTERFACE FOR IEEE-488 (GPIB/HPIB)

- INCLUDES INSTALLABLE DOS DEVICE DRIVERS
- 1 OF 6 INTERRUPT LEVELS
- 1 OF 2 DMA CHANNELS
- UP TO 4 BOARDS PER COMPUTER
- CONTROLLER / TALKER / LISTENER
- CUSTOM SOFTWARE SUPPORT AVAILABLE
- COMPATIBLE WITH MOST IEEE488 SOFTWARE PACKAGES FOR THE IBM PC
- QUANTITY DISCOUNTS

VISA MC AMEX

Call today for datasheet!!

B&C MICROSYSTEMS

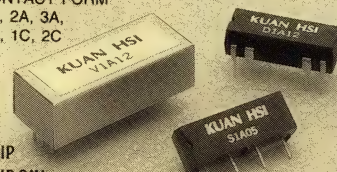
355 West Olive Ave, Sunnyvale, CA 94086
PH: (408)730-5511 FAX: (408)730-5521 TELEX: 984185

CIRCLE NO 756

REED RELAYS & SOLID STATE RELAYS

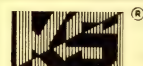
CONTACT FORM

1A, 2A, 3A,
1B, 1C, 2C



- DIP
- DIP-SML
- DIP-SMJ
- SIP
- VARI-PACK 1
- VARI-PACK 2
- GENERAL TYPE
- MICRO MINI

With more than 5 years experience, we supply the highest quality Reed relays at competitive price. We offer ultra-fast delivery-orders of up to 10,000 pieces are filled in just one day.



Manufacturer

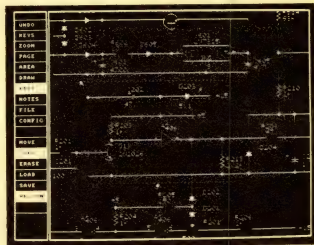
KUAN HSI ELECTRONICS CO., LTD.

P.O. Box 94-150, Taipei, Taiwan, R.O.C.
Tel: 886-2-946-7741, 946-6051
Fax: 886-2-9434304

CIRCLE NO 757

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

SCHEMA II Schematic Capture



FREE Demo Disk: 1-800-553-9119

SCHEMA's success is the talk of the CAE industry and *thousands* of satisfied SCHEMA owners know why. Incredible speed, ease of use, and power have made SCHEMA a best-selling schematic capture program for engineering professionals the world over.

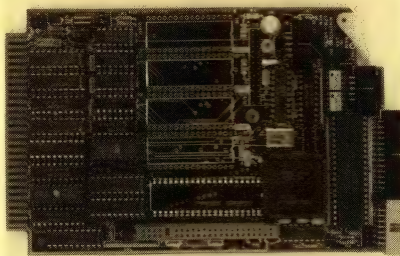


Now, SCHEMA II is available. SCHEMA II sells for \$495 and supports most common IBM PC/XT/AT configurations. Please call today for a free SCHEMA II demo disk.

OMATION

In Texas Call (214) 231-5167

CIRCLE NO 758



CMOS STD BUS SINGLE BOARD COMPUTER

The LPM-SBC40 is a CMOS STD-BUS Single Board Computer that is designed for industrial applications. The LPM-SBC40 uses the NEC V40 microprocessor, up to 256K bytes of EPROM, 384K bytes of battery backed-up SRAM, real time clock, two RS-232 serial channels with RS-422/485, watchdog timer and power fail logic, 5, 8 and 10 MHz.

WinSystems

Box 121361, Arlington, TX 76012
817/274-7553

CIRCLE NO 759



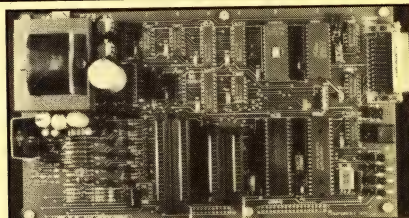
DATA ACQUISITION AND INDUSTRIAL CONTROL PLUG-IN BOARDS

MetroByte's New Free 248 page handbook describes their complete line of Data Acquisition products. The new handbook introduces many new products including: PC Instruments, High Performance Frame Grabbers, Image Processors and Vision Products.

The Handbook provides complete product information on all boards for the IBM PC/XT/AT & PS/2, Microchannel, Apple II, Macintosh SE/II and VME bus computers.

MetroByte Corp., 440 Myles Standish Blvd., Taunton, MA U.S.A. 02780. (617) 880-3000.

CIRCLE NO 760



UNIVERSAL E(E)PROM PROGRAMMER KITS FROM \$95

- No personality modules; Menu-driven device selection.
- On board power supply (110/220V AC).
- Direct technical support; Full 1 year warranty.
- User friendly software; Complete help menu.
- Quick pulse algorithm (2725e under 60 sec).
- Programs 27xx to 1 Mbit; 25xx, 68xx, CMOS; EEPROMS.
- Micros: 8741, 8742, 8748, 8748H, 8749, 8749H & more.
- IBM-PC, Apple, CPM or Unix driver; Autobaud RS232.
- Offset/split Hex, Binary, Intel & Motorola 8,16,32 bit.
- Manual with complete schematics.

VISA MC AMEX Call today for datasheets!!

B&C MICROSYSTEMS

355 WEST OLIVE AVE. SUNNYVALE, CA 94086
PH: (408) 730-5511 FAX: (408) 730-5521 TELEX: 984185

CIRCLE NO 761



Great Designs Start With Tango-Schematic.™ Just \$495.

Designs quickly come to life with Tango-Schematic's easy-to-use drawing editor and extensive component libraries. Features four line types, four text sizes, repeat and block functions, unique built-in word processor. Includes DRC, BOM, Wire List, Net List outputs and crisp plots, prints, or laserprints. The perfect front end to our popular Tango-PCB and Tango-Route board design systems.

For IBM PC/XT/AT/PS2. Just \$495. Full-function Demo Package: \$10. Order toll-free 800 433-7801. VISA/MC. Thirty-day money back guarantee.

ACCEL Technologies, 7358 Trade St., San Diego, CA 92121
Outside N., S. America contact HST Technology (Australia)
Phone: 61-02-34-8499 FAX: 61-02-23-8771

CIRCLE NO 762



New! TangoTools
Eight Money-Saving
Tango Utilities—Just \$295

Glide Through PCB Design.

TangoPCB™ Create the toughest board designs with powerful layout software that's a snap to use. Function-rich Tango-PCB supports eight layers, 1 mil grid, OrCAD™ or Schema™ netlist input, print/plot/photoplot output, and more.

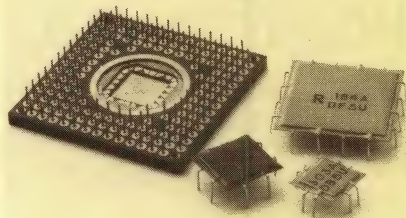
TangoRoute™ Get impressive completion rates and remarkable speed with Tango-Route, a four layer, eleven pass autorouter.

Just \$495 each.

For IBM PC/XT/AT/PS2. Compare features and you'll buy Tango. Or try full-function Demo Package, just \$10. Order toll-free: 800 433-7801. VISA/MC. Thirty-day money back guarantee.

ACCEL Technologies, 7358 Trade St., San Diego, CA 92121

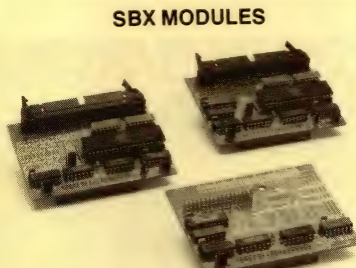
CIRCLE NO 762



STOP NOISE IN PGA, LCC PACKAGES

PGA MICRO/Q decoupling capacitors provide low-inductance, high-frequency noise decoupling for PGA, LCC packages on complex board layouts. Fit under PGA or LCC sockets use no extra board space. Choose from many pinout configurations. **Rogers Corp.**, 2400 S. Roosevelt St., Tempe, AZ 85282. 602/967-0624.

CIRCLE NO 764



SBX MODULES

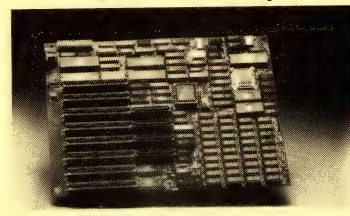
We've upgraded our SBSxSCSI module to support Block-Mode Psuedo-DMA transfers. That means CPUs without DMA can increase transfer speeds by not polling for READY on every byte. We've also added an optional Centronics-compatible printer port (SBSxSCSI/CEN). If you only need the printer port, save money with our low-cost SBSxSBC module. We also offer a Floppy-Disk Controller module (SBSxSBC) that handles 3 1/2", 5 1/4", and 8" drives with SD, DD and HD formats.

Call or write for more information.

Single Board Solutions, Inc.
20045 Stevens Creek Blvd.
Cupertino, CA 95014
(408) 253-0250

CIRCLE NO 765

80286 'XT' Motherboards \$104 In Quantity



- 5 Times More Power Than An 8 MHz Turbo XT
- High-Speed 80286 Processor. PC & XT Versions
- Sockets for 80287 Chip & 1 MB Zero Wait-State RAM
- Includes Automatic Disk Cache Above 640K RAM
- BIOS and 8-Slot Expansion Bus Compatibility Guaranteed
- American Made; 30 Days Money-Back; 2 Year Warranty
- List price (Zero RAM): \$295

SPECIAL OFFER: One unit for quantity purchase evaluation: \$199 Evaluation Purchase Earns \$100 or \$199 Credit Toward Subsequent Purchases - Call For Details
Faster Boards Available

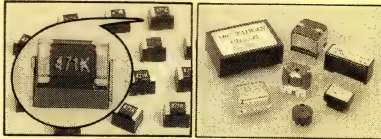
WAVE MATE, INC.

2341 205th Street, #110, Torrance, CA 90501
Tel: (213) 533-8190 Fax: (213) 533-5940

CIRCLE NO 766

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

CHIP COILS DC-DC CONVERTERS PULSE TRANSFORMERS



Our Chip Coils is good for your miniaturization & surface mounting. DC-DC Converters, pulse transformers & band pass filters is now complete with excellent functions. We also supply choke coils, power chokes, linearity coils, toroidal coils, pulse transformers, coupling transformers, power transformers and others. Send for details today.!



OEM and Agent
Inquiries Invited

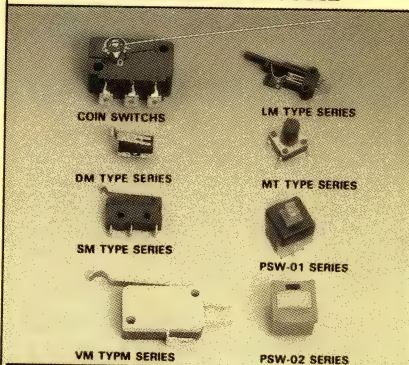
ABC TAIWAN ELECTRONICS CORP.
No. 422, Sec. 1, Yang Fu Rd., Yangmei 32627,
Taoyuan, Taiwan, R.O.C.
Tel: (03) 4788088, Telex: 32379 ABCEC
Fax: (03) 4755503

CIRCLE NO 767

ZIPPY SWITCHES

NO: E91274

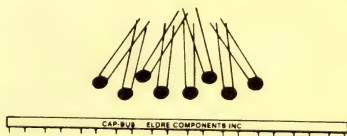
*FULL DETAILS AND SAMPLES
ON REQUEST
*OEM ARE WELCOME



ZIPPY SHIN JIUH CORP.
P.O. Box 10184 SHIN TIEN TAIPEI HSIEN, TAIWAN, R.O.C.
TEL: (02) 9188512-5 TLX: 33418 ZIPPY FAX: 886-2-9155765

CIRCLE NO 770

ELIMINATE DECOUPLING CAPACITORS



CAP-BUS® CAPACITOR/BUS BAR

Eliminate the decoupling capacitors and the power and ground traces from your PCB for more reliability. CAP-BUS® has a distributed capacitance of .05 micro-farads per lin. in., at 50 VDC with low inductance and low impedance. The capacitor and the bus bar have been joined together for CAP-BUS®; a more efficient capacitive decoupled power distribution system, increasing IC density on a two sided board.

ELDRE COMPONENTS, INC. 1500 Jefferson Rd.
Rochester, NY 14623
(716) 427-7280

CIRCLE NO 773

IEEE-488

PC/AT/PS2

GP-IB, HP-IB CONTROL FOR YOUR PC, PC/AT and IBM PERSONAL SYSTEM/2™

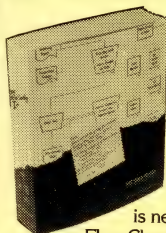
- Control instruments, plotters, and printers.
- Supports BASIC, C, FORTRAN and Pascal.
- Fast and easy to use. Thousands sold.
- Software library. Risk free guarantee.



Capital Equipment Corp.
99 South Bedford St.
Burlington, MA. 01803

FREE demo disk. Call (617) 273-1818

CIRCLE NO 768



Flow Charting II+ The New Plus for Fast Flowcharting

FLOW CHARTING
is new! It's now

Flow Charting II+, with more speed
+ more functions + more printing options;

- 10 text fonts; 26 shapes; • Line mode can stop at a shape; • Backspace key can erase a line to its origin; • Free text entry anywhere, or select auto-centering; • Vertical or horizontal printing; one chart or multiple charts.

Used by Fairchild, Bechtel and more than 500 other major corporations. Edit quickly and accurately — even major edits — with Flow Charting II+, the Specialist.

See your retail store or call:

PATTON & PATTON
Software Corporation

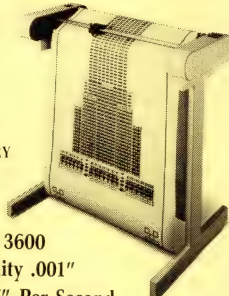
1-800-525-0082, Outside California
408-629-5376, California/International

CIRCLE NO 771

"D" SIZE PLOTTER

\$2295⁰⁰
RETAIL

\$1695⁰⁰
INTRODUCTORY
OFFER



- Model PC 3600
- Repeatability .001"
- Speed at 7" Per Second
- Vacuum Paper Hold Down
- High Resolution Circles: Suitable for PCB Artwork

(415) 490-8380 **ZERICON**
STEVENSON BUSINESS PARK
BOX 1669 • FREMONT, CA 94538

CIRCLE NO 774

PC-Based Servo System



System Elements: • Plug-in Motion Controller for 1, 2 or 3 Axes • Servo Motor • Encoder • Design Software for PC • Power Driver & Supply • Cables **Base Price \$1145**

Software Features: • Servo Modeling and Analysis • "Live" Communication • Storage Scope • Step and Frequency Response • Auto Tuning • Linear and Circular Interpolation • Contouring • User-Definable Programs **Demo Disk \$50**

Galil Motion Control
1054 Elwell Court, Palo Alto, CA 94303
(415) 964-6494

CIRCLE NO 769

Introduce
new products
and literature

Build
awareness in
the marketplace

Supplement
your advertising
campaign

EDN Product Mart

CIRCLE NO 772

IEEE-488 CONTROLLER FOR PS/2

MODELS 50, 60, 80

- GPIB Compatibility
 - Control Up to 14 Devices
 - Selectable Addressing
 - Software Included
- 1-800-553-1170**

QUA TECH
INCORPORATED

478 E. Exchange St., Akron, OH 44304
TEL: (216) 434-3154 FAX: (216) 434-1409
TLX: 5101012726

CIRCLE NO 775

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



Schematic and PCB Software

Create and revise schematics and PCBs quickly and simply with **HiWIRE-Plus**® and your IBM PC. Use symbols from HiWIRE-Plus's extensive library, modify them, or create your own quickly and painlessly. Netlist, bill-of-materials, and design-checking utilities are included. **HiWIRE-Plus** is \$895 and comes with a thirty-day money-back guarantee.

Wintek Corp.

1801 South St., Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO 776

A Lot For A Little

Reach 137,000
specifiers of electronics
components, equipment,
and systems for
only \$780.

EDN Product Mart

CIRCLE NO 779

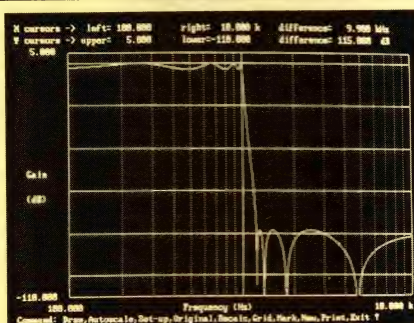


EPROM PROGRAMMER

Model EP-2B-87 with RS-232, MS-DOS or CP/M software. Programs: 2708, 2716, 2716B, TMS2716, 2732, 2732A, 2732B, 2532, 2532A, 2764, 2764A, 2712B, 27128A, 27256, 27512, 27513, 2564, MCM68764 N-MOS and C-MOS EPROMs; 2816A, 2864A EEPROMs; 8751H, 38E70 MPU, Intel, Motorola, and Tektronix formats. Stand alone copy, verify, edit, 17 RS-232 commands. \$395 for 8K byte buffer. Personality modules \$18 to \$36.

Optimal Technology
Earlsville, VA 22936
804-973-5482

CIRCLE NO 777



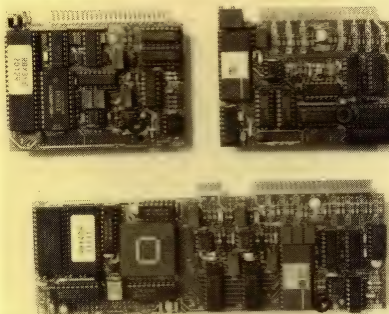
NEW! ADVANCED ACTIVE FILTER DESIGN SOFTWARE

Version 3.0 designs Lowpass, Highpass, Bandpass, Bandstop and ALLPASS filters with Butterworth, Chebyshev, elliptic and Bessel response. NOW calculates values for National MF-10, Reticon, MFB, VCVS, biquad and state variable filter circuits. Interactive graphics for group or phase delay, gain, phase, impulse and step response of the complete filter or individual section. Combine filters for system design/analysis. Modify circuits to observe effects (\$525) for IBM PC, XT, AT, PS/2

SPICE FILE CONVERSION OPTION AVAILABLE

RLM Research
P.O. Box 3630
Boulder, CO 80307-3630 (303) 499-7566

CIRCLE NO 780



SBX ANALOG I/O MODULES. Up to 16 analog inputs and 8 analog outputs w/12 bit resolution on one card. Throughput rates from 3 kHz to 59 kHz. TTL or CMOS. Nonintelligent or intelligent w/FIFO I/O buffer and many pre-programmed modes of operation. Input filters, prog. gain amp, sample-hold.

ROBOTROL CORP

16100 Caputo Dr, Morgan Hill, CA 95037
(408) 778-0400

CIRCLE NO 783

WE PROVIDE SOLUTIONS TO MANY INTERCONNECT PROBLEMS...



- Test Adapters (Socketed LCC/PLCC/PGA)
- Test Clips (Surfaced Mounted SOIC/PLCC)
- 150 Types of Prototyping Board Adapters
- 125 Types of Programming Socket Converters
- Many Types of Emulator Pod Converters
- PGA/PLCC Extraction/Insertion Tools
- And Much, Much More...



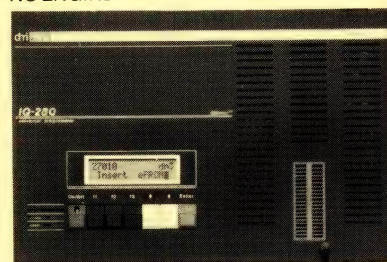
Emulation Technology, inc.

STATE OF THE ART VLSI and SURFACE MOUNT ACCESSORIES

2368-B Walsh Ave. • Bldg. D • Santa Clara, CA 95051
TEL: (408) 982-0660 • FAX: (408) 982-0664

CIRCLE NO 778

NO ENGINEER SHOULD BE WITHOUT ONE



America's most advanced Personal Programmer

The Digital Media IQ-280 can program 40 PIN devices.

The most advanced firmware controlled pin driver system available means you never have to worry about buying another expensive module or PAK again. The IQ Personal Programmer line offers the power and features comparable to many of the \$5,000 programmers, but at a fraction of the costs.

Support for CMOS, NMOS, ECL, Bipolar, PROMs, EPROMs, eEPROMs, PLDs, ePLDs, iFLs, FPLDs, up to 40 pin DIP packages.

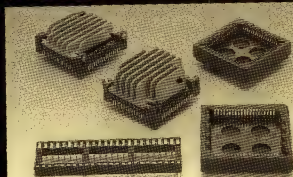
Altera, AMD, Atmel, Cypress, Excel, Fairchild, Fujitsu, GI, Hitachi, Hughes, Intel, Lattice, Mitsubishi, Motorola, National, NEC, MMI, Samsung, Seel, Sierra, Signetics, SMOS, TI, Toshiba, Waterscale and more. ALMOST 1000 DEVICES!

Whatever your need is, Digital Media can help you solve it. And you won't believe how little it costs.

Call (714) 751-1373 to receive a complete product specification package immediately.

CIRCLE NO 781

WINPOINT A FULL RANGE OF CONNECTORS & SOCKET



IC SOCKETS-8, 14, 16, 18, 20, 22, 24, 28, 40, 42, 48 contact
LCC SOCKET-68 contact
PLCC SOCKET-28, 32, 44, 52, 68, 84 contact series

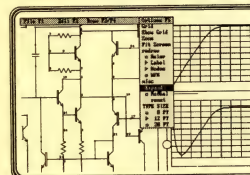


Winpoint Electronic Corp.

P.O. Box 89-80, Taipei, Taiwan, R.O.C. Office: No. 47, Chi-Wei St., San Chung City, Taipei, Taiwan, R.O.C.
Tel: (02) 986-0208, 984-0209
Telex: 34227 WINPOINT Fax: 886-2-9838555

CIRCLE NO 782

Analog Circuit Simulation



**NEW
SPICE_NET
\$295.00**

Make SPICE input files from schematic drawings using pull down menus and a mouse to draw and connect parts. Use an IBM PC with any UC Berkeley compatible SPICE program.

Simulation Programs

for
**IBM
PC's
from
intusoft**

■ **IS_SPICE, \$95.00.** Performs AC, DC and Transient analysis.

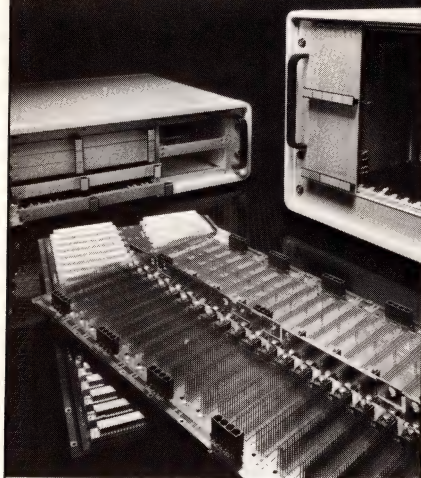
■ **PRE_SPICE \$200.00:** Adds Monte Carlo Analysis, Sweeps, Optimization, libraries and algebraic parameter evaluation.

■ **Intu_Scope \$250:** A graphics post processor works like a digital oscilloscope. Easy to use with all the waveform operations you will ever need.

CIRCLE NO 784

(213) 833-0710
P.O. Box 6607
San Pedro, CA
90734-6607

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



WHAT'S NEW IN VME PACKAGING

Ready to use, 32-bit, integrated

VECTOR-PAC® system enclosures with

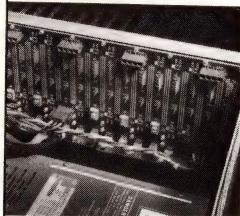
combined J1/J2 backplane, power

supply and cooling fans, assembled

in a fully accessible, removable

sub-rack. Plug in your cards and go.

See us at Electro Booth 1409



**MASSIVE
BUSBAR POWER
DISTRIBUTION**
3U-9U, 5-21 slot,
J1/J2 backplane
175-450 watt power
supply, U.L. Listed
standard and
custom models.

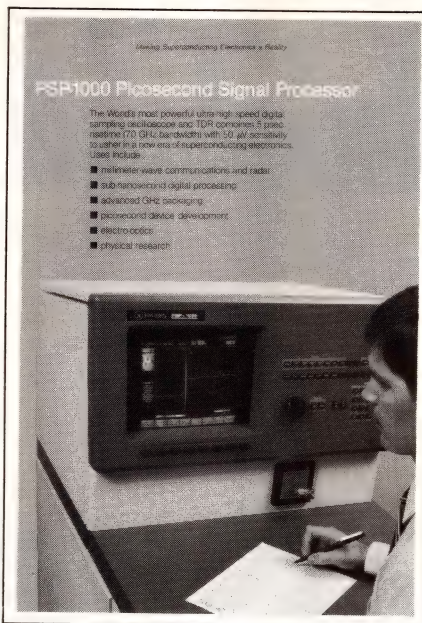
*First Vectorboard
Now VME bus*

VECTOR ELECTRONIC COMPANY
12460 Gladstone Avenue
Sylmar, CA 91342
818/365-9661 FAX 818/365-5718

800/426-4652 In CA
800/423-5659 Outside CA

119

LITERATURE

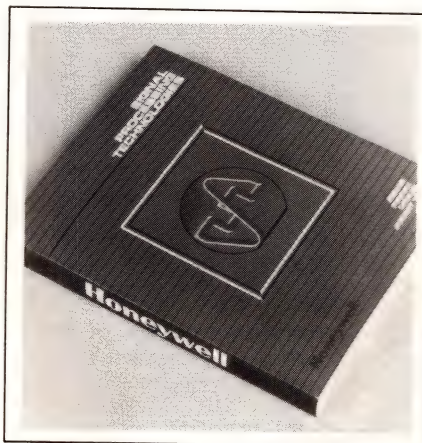


Superconducting electronics explored

The 8-pg brochure *PSP-1000 Pico-second Signal Processor* describes the combination of a digital sampling oscilloscope and time-domain reflectometry which, according to the vendor, is functioning at the threshold of superconducting electronics. The publication presents background information, annotated illustrations, and specifications.

Hypres Inc., 500 Executive Blvd, Elmsford, NY 10523.

Circle No 435



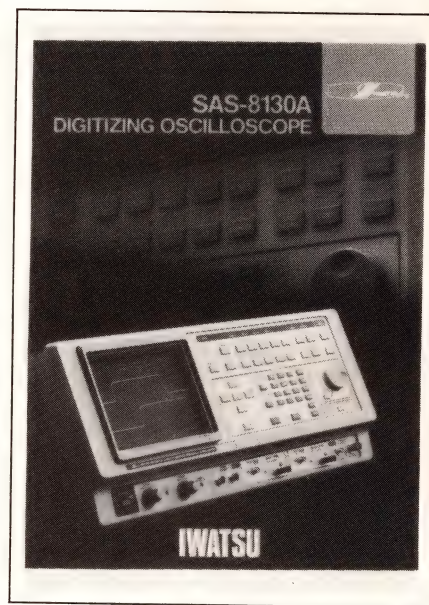
Catalog contains analog products

The 520-pg 1988 Analog Product Catalog categorizes A/D converters, comparators, track/hold ampli-

fiers, switched capacitor filters, and D/A converters. It also includes advance information about many new products to be introduced this year, as well as application notes on flash converters, video DACs, and switched capacitor filters.

Honeywell Inc., Signal Processing Technologies, 1150 E Cheyenne Mountain Blvd, Colorado Springs, CO 80906.

Circle No 436



Scope helps you analyze high-speed waveforms

The vendor's 10-pg brochure describes its SAS-812A digitizing oscilloscope with which you can observe and analyze ultra-high-speed waveforms. It discusses features such as jitter reduction, an auto-trigger function, and remote control with an external controller via RS-232C and IEEE-488 STD interfaces. Detailed descriptions, including illustrations, provide more information about applications such as rise and fall times, and evaluation of wide bandwidth differential amplifiers. The publication also includes an overview of the display screen, as well as specifications and options for the scope.

Iwatsu Instruments, 430 Commerce Blvd, Carlstadt, NJ 07072.

Circle No 437

High Precision ...Absolutely

There's no such thing as "almost precise." That's why you should select Hybrid Systems—the leader in 16-bit hybrid and monolithic analog signal processing components.

Your demand for high precision is absolute. So is ours. Since we introduced the industry's first 18-bit DAC five years ago, Hybrid Systems has dedicated itself to creating high precision analog signal processing components that simply will not compromise your performance, or our position of acknowledged leadership in the field. As a result, we now offer an impressive family of 16-bit products designed to make high precision as accessible—as it is essential—for your demanding applications.

In DAC's, choose from an exceptionally wide range of products including monolithic, micro-processor compatible, voltage output, and current output components. You can also select products that feature low cost or high accuracy—all with 16-bit precision.

In other areas, Hybrid has both the only true 16-bit hybrid ADC on the market *and* the fastest with a 15 μ sec. conversion time. Just as important, the additional 16-bit products presently under development will continue the Hybrid Systems tradition of precision with breakthroughs in speed, cost, and accuracy in every type of analog signal processing component, including Data Acquisition Systems.

High precision. We insist on it. We deliver it. And we will never compromise it in any of our components, or in any of your applications... because it's simply too important to both of us.

GREAT NEWS! Hybrid Systems now offers a brand new, revolutionary 16-bit Sample/Hold component with dielectric absorption compensation. For more information, or to order our new catalog, call or write us today.

22 Linnell Circle, Billerica, MA 01821
617-667-8700.

Sipex Hybrid Systems
Corporation Division



Software development courses offered

This brochure describes the courses in languages, operating systems, and software engineering that are available. Four new courses in Advanced C Programming comprise Hands-On Workshop, Software Requirements and Specifications, Software Quality Assurance and Test-

ing, and Software Maintenance. The publication discusses the subjects and applications covered, hands-on activities, benefits, materials provided, authors and instructors, and locations. Three- and four-day programs, from \$1095 to \$1395.

Integrated Computer Systems,
Box 3614, Culver City, CA 90231.

INQUIRE DIRECT

Shouldn't Our Award Winning MDS...



8051
80515
83C154
6301
68HC11

64180
Z180
Z80/Z80H
8085
NSC800

..Be on your Design Team?

We've won a major award from a prestigious microelectronics applications centre.
For innovation in design. In PC-Based MDS's.

We designed-in integration: Program development, in-circuit emulation, execution analysis and PROM programming. In one unified system. So you can have it all at your fingertips. With one interface to learn. And one number to call.

We designed-in flexibility: A modular adaptable system that supports many device families. Through easy to install, inexpensive upgrades. So you keep your options open. And make a lasting investment.

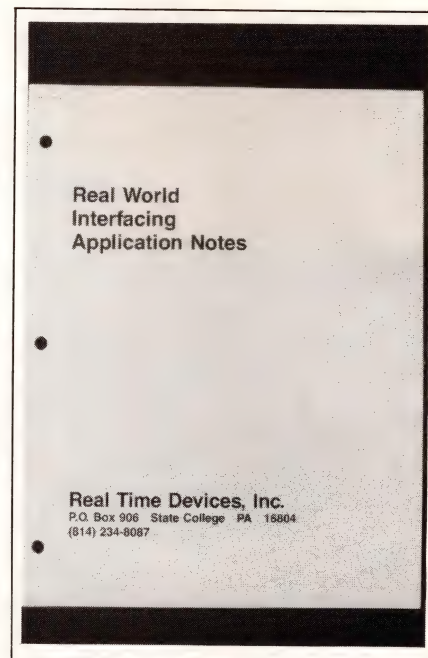
We designed-in power: Unlimited breakpoints. High performance trace. Intuitive user interface. High level languages. Fully symbolic debug. So you stay in control of your project. And finish on time.

Make an award winning decision. Contact us NOW!

Ashling Microsystems Ltd., Limerick, Ireland. + 353-61-334466

DISTRIBUTORS
AUSTRIA (0222) 82 74 74-0, BELGIUM (02) 241 64 60,
FRANCE (1) 39 54 91 13, 45 34 75 35, ISRAEL (03) 493211-9
ITALY (02) 49 82 451, NETHERLANDS (01720) 43221
SWEDEN (08) 739 00 45, SWITZERLAND (01) 723 14 10
UNITED KINGDOM (0628) 32517, W.GERMANY (089) 8 58 02-0


The Development Systems Company



App notes address interfacing problems

The publication *Real World Interfacing Application Notes* contains 12 application notes that shed light on common interfacing problems in the laboratory and in industry. It provides tips and expounds on useful circuits for interfacing thermocouples, thermistors, solid-state temperature sensors, pH probes, and piezoresistive pressure transducers to personal computers. It also deals with solid-state relays to activate 110V ac lines, sensing incident light, and selecting an appropriate method of A/D conversion. These notes do not provide solutions for a particular interfacing problem, but rather guide you in the right direction. They provide sample circuits, and list references and companies for further information.

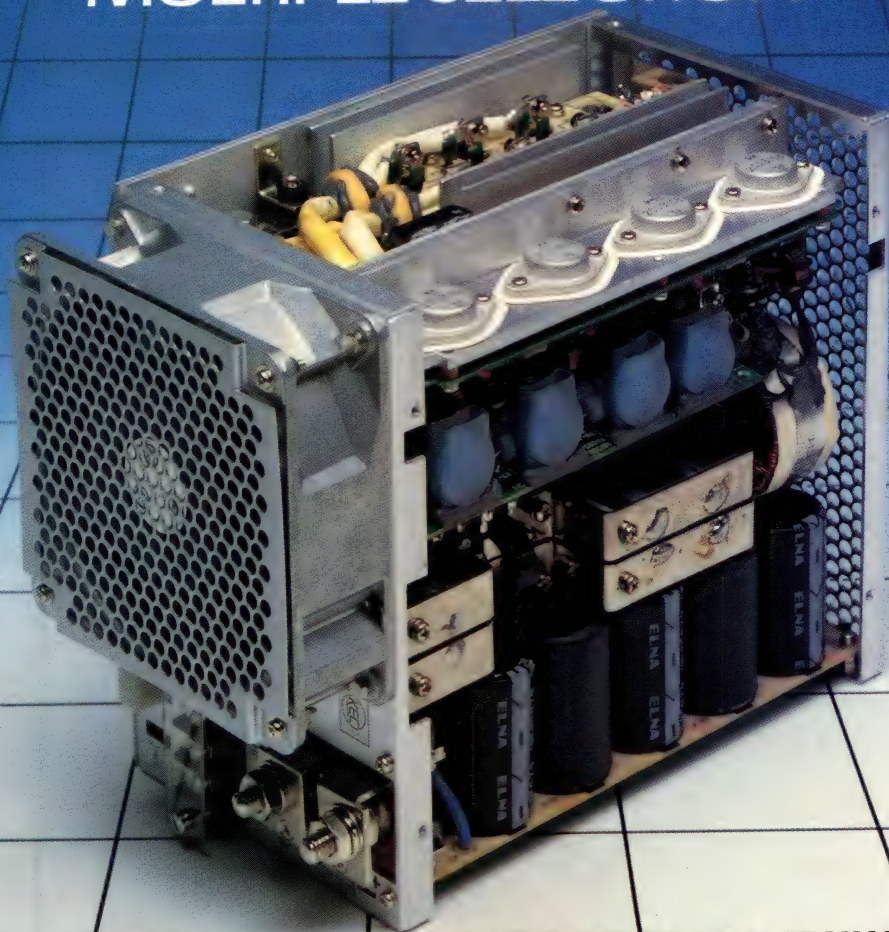
Real Time Devices Inc, Box 906,
State College, PA 16804.

Circle No 439

Applications for power MOSFET IC

Application Note 28 focuses on the many uses of the TSC429 universal power MOSFET driver IC. It details the IC's parameters and tells you how the product can help with your

KE SERIES HIGH-POWERED, SINGLE-OUTPUT MULTIPLE SELECTION



CHOOSE FROM A BROAD RANGE OF OUTPUT WATTAGES

KEC ELECTRONICS, Inc.'s KE SERIES of high-power, single out-put DC switching power supplies combine high power and compact packaging to meet a broad range of applications. They are available in 750 and 1000 Watt configurations, with additional outputs up to 3KW in the near future. KEC's quality manufacturing ensures reliable performance and operating integrity under the severest environments.

The KE SERIES single output switching power supplies feature PALS (Programmed Automatic Load Sensing) for load line drop compensation, power failure signal output, and remote programming. Additional features include voltage regulation, fan-cooling and built-in protection against overload and overvoltage conditions. All units are UL and CSA approved and

EMI filter conforms to FCC Class A on conduction noise.

KEC makes it easy to choose the exact power supply to meet your standards. Select from over 200 standard products or have KEC's engineers custom-design a precision switching power supply just for you.

Discover the real Multiple Choice in power supplies—Discover KEC!! Write for your FREE literature and information kit or call KEC toll-free today!

1-800-255-5668



KEC ELECTRONICS, INC.
20817 Western Avenue, Torrance,
CA 90501
(213) 320-3902, FAX (213) 618-1197

"KEC—BRINGING MORE POWER TO YOU"

designs. The paper shows typical applications for the part—as a small motor controller, as a voltage doubler, as a voltage inverter, and as a high-power pulse-transformer driver.

Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039.

Circle No 440

Listing of test and measurement equipment

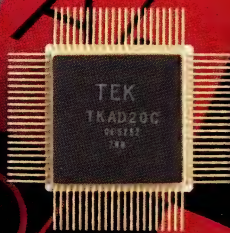
The vendor's 1988 Catalog of Laboratory and Field Service Test & Measurement Equipment contains more than 75 new products ranging from digital multimeters to digital storage oscilloscopes. The 36-pg booklet also lists complete specifications for at least 400 items, includ-

YOU CAN'T BEAT TEK AT ITS OWN GAME.

And 250 MSPS A/D Converters with 1 GHz Track and Hold is the game.

Don't settle for second best. We have what you need now.

Call Tek direct:
1-800-835-9433 Ask
for IC Standard
Products.



Tektronix
COMMITTED TO EXCELLENCE

Copyright © 1988, Tektronix, Inc. All rights reserved. CHP-117

CIRCLE NO 52



ing multimeters, oscilloscopes, circuit analyzers, power equipment, signal generators, frequency counters, and a full range of accessories.

Anasco Corp, 42A Cherry Hill Dr, Danvers, MA 01923.

Circle No 441



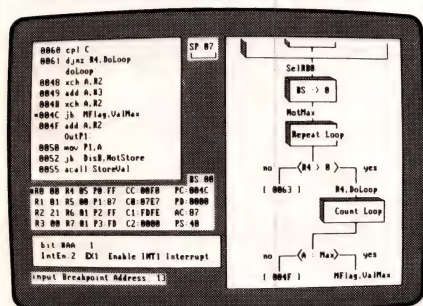
Brochure details VME power supplies

This 4-pg pamphlet outlines the specifications and features of the company's 200 and 400W VME plug-in/multiple output power supplies. It also includes voltage/current selector charts, as well as outline and pin-connection drawings.

Electro-Dyn Corp, 90 Sparta Ave, Sparta, NJ 07871.

Circle No 442

IBM-PC based microcomputer development tools!



(8051 debug/simulator shown)

Your IBM PC can Assemble, debug and program (EPROM) code for these popular microcomputers:

	DEBUG	XASM	PROG
8096	✓	✓	✓
8051	✓	✓	✓
8049	✓	✓	✓
7000	✓	✓	✓
8088	✓		✓
8085		✓	✓
320		✓	✓
28		✓	✓
Step your code, watch registers & memory change, interrupts occur, stack push & pop. Flowgraph auto-documents code! You set breakpoints & register traps, count machine cycles, and scan source code and symbols. Single-key commands prompt for arguments if needed. Have more fun and get more done!	\$595 except 8096 and 8088	\$295	\$245 Kit form

debug demo diskette and manual only \$39.50



Cybernetic Micro Systems
P.O. Box 3000
San Gregorio, CA 94074 U.S.A.

(415) 726-3000 • Telex 171135 Attn: Cyber

CIRCLE NO 59

EDN May 12, 1988

LITERATURE

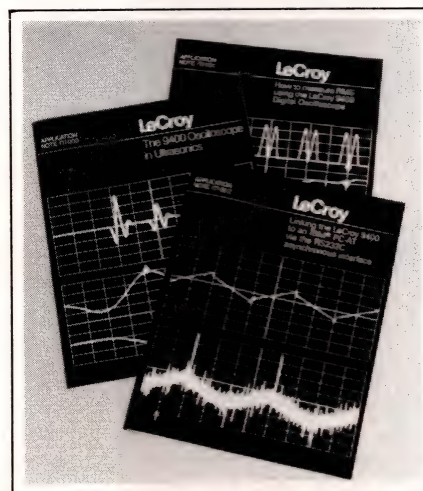


Heeding data storage needs

The vendor's 8-pg brochure features DEC-compatible storage-module-disk interconnect subsystems and digital-storage, architecture-compatible disk drives. It discusses each product's advantages and provides specifications and illustrations.

Emulex Corp., Box 6725, Costa Mesa, CA 92626.

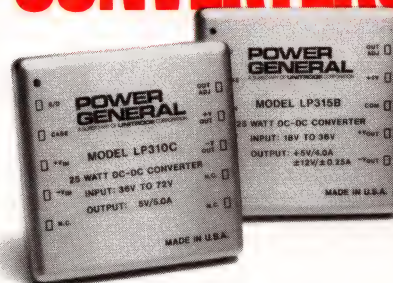
Circle No 443



How to use scope in three different applications

This series of application notes, *How to Measure RMS Using the LeCroy 9400 Digital Oscilloscope*, *Linking the LeCroy 9400 to an IBM PCAT Via the RS-232C*, and *The 9400 Oscilloscope in Ultrasonics*, examines three uses of the vendor's Model 9400 digital oscilloscope. AN ITI 001, the first note, presents a step-by-step procedure to calculate any waveform rms value. The second note, AN ITI 002, presents communication protocol and provides a short Basica interactive program that brings the remote control of Model 9400 into play. Finally, AN

ULTRA LOW PROFILE WIDE INPUT 25W, DC/DC CONVERTERS



Got an "on card" power distribution problem? Not enough real estate for a big modular supply? Don't want to use two card slots for any of the readily available "high profile" converters?

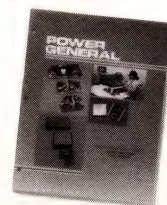
Well, Power General has the LP-310/315 solution. These compact converters utilize surface mount manufacturing, high frequency design and unique thermal management techniques to achieve performance features such as:

- 0.375 inch height
- 25 watts output power
- > 500,000 hour MTBF
- 2:1 input range
- 500 VDC input/output isolation
- Industry standard Pin-out
- Full five year warranty

Power General, utilizing the latest technology to provide complete, innovative solutions to your power needs.

FREE HANDBOOK!
Call for your free
1988 Power Supply
Handbook

**Put
Power General
To Work For You!**



POWER GENERAL

A SUBSIDIARY OF **UNITRODE CORPORATION**
152 Will Drive, P.O. Box 189, Canton, MA 02021
(617)828-6216 TWX: 710-348-0200
FAX: 617-828-3215

CIRCLE NO 53

THINK
LOW POWER
CONSUMPTION

THINK
SMALL

Think CRYSTAL OSCILLATORS
from Statek Corporation. The SQXO
surface mountable oscillators are housed in
a standard 24-pin CLCC and are available in a
variety of unique packages and types of circuitry
over a frequency range of 1 Hz to 32 MHz. The
oscillators test to 883 Mil Spec and, whether
leaded or surface mountable, are CMOS and TTL
compatible...all have long term
stability and high shock
characteristics.
Call for additional information on
our SMALL WONDERS!



STATEK CORPORATION
512 N. Main Street
Orange, CA 92668
(714) 639-7810; Telex 67 8394
Made in the U.S.A.

CIRCLE NO 60

"Surface-Mount Technology Design Project" by Steve Leibson



**EDN
REPRINTS**

Now you can order copies of EDN magazine's exclusive hands-on surface-mount design series. This 48-page, four-color reprint follows the progress of EDN editor Steve Leibson as he designs a 2 Mbyte memory board using surface-mount technology. Leibson takes you from his initial concept through to the finished working product, and includes typical problems you might encounter and objectively reports about both good and bad design decisions made along the way.

Don't miss this exclusive reprint that covers the newest design option that electronic engineers can use for designing innovative products. This latest reprint is yours for only \$7.95 (UPS) and \$10.95 (non-USA).

Mail coupon to: EDN Reprints, EDN Magazine,
Cahners Building, 275 Washington Street, Newton, MA 02158-1630

Please send _____ copies of *A Designer's Guide to Surface-Mount Technology*
at \$7.95 (UPS) or \$10.95 (non-USA)*

Please print clearly. This is your mailing label.

Foreign checks must be drawn on
a US Bank, issued in US currency.

Name _____ EDN051288

Title _____

Company _____

Address _____

City _____ State _____ Zip _____

*Check or money order made out to EDN REPRINTS must accompany each order. No COD. Mass. residents
add 5% sales tax.

LITERATURE

ITI 003 outlines traditional nonde-
structive-test ultrasonic waveforms.

LeCroy Corp, 700 Chestnut
Ridge Rd, Chestnut Ridge, NY
10977.

Circle No 444



Application Note 14
July 1985

Designs for High Performance Voltage-to-Frequency Converters

Jim Williams

Monolithic, modular and hybrid technologies have been
used to implement voltage-to-frequency converters. A
number of types are commercially available and several
parameters are used to rate many requirements in
many cases. However, very high performance or special
characteristics are required and available units will not
work in these instances. V-F circuits specifically re-
quire that the desired characteristics are required. This ap-
plication note presents examples of circuits which offer
superior performance, particularly their commercial
availability. V-F circuits are discussed in two sections.
Section 1 presents the characteristics of the various
types of V-F circuits. Section 2 presents the characteristics
of the various types of V-F circuits. Section 3 presents
the characteristics of the various types of V-F circuits.
Section 4 presents the characteristics of the various
types of V-F circuits. Section 5 presents the charac-
teristics of the various types of V-F circuits. Section 6
presents the characteristics of the various types of V-F
circuits. Section 7 presents the characteristics of the
various types of V-F circuits. Section 8 presents the
characteristics of the various types of V-F circuits. Sec-
tion 9 presents the characteristics of the various types
of V-F circuits. Section 10 presents the characteristics
of the various types of V-F circuits. Section 11 pre-
sents the characteristics of the various types of V-F
circuits. Section 12 presents the characteristics of the
various types of V-F circuits. Section 13 presents the
characteristics of the various types of V-F circuits. Sec-
tion 14 presents the characteristics of the various types
of V-F circuits. Section 15 presents the characteristics
of the various types of V-F circuits. Section 16 pre-
sents the characteristics of the various types of V-F
circuits. Section 17 presents the characteristics of the
various types of V-F circuits. Section 18 presents the
characteristics of the various types of V-F circuits. Sec-
tion 19 presents the characteristics of the various types
of V-F circuits. Section 20 presents the characteristics
of the various types of V-F circuits. Section 21 pre-
sents the characteristics of the various types of V-F
circuits. Section 22 presents the characteristics of the
various types of V-F circuits. Section 23 presents the
characteristics of the various types of V-F circuits. Sec-
tion 24 presents the characteristics of the various types
of V-F circuits. Section 25 presents the characteristics
of the various types of V-F circuits. Section 26 pre-
sents the characteristics of the various types of V-F
circuits. Section 27 presents the characteristics of the
various types of V-F circuits. Section 28 presents the
characteristics of the various types of V-F circuits. Sec-
tion 29 presents the characteristics of the various types
of V-F circuits. Section 30 presents the characteristics
of the various types of V-F circuits. Section 31 pre-
sents the characteristics of the various types of V-F
circuits. Section 32 presents the characteristics of the
various types of V-F circuits. Section 33 presents the
characteristics of the various types of V-F circuits. Sec-
tion 34 presents the characteristics of the various types
of V-F circuits. Section 35 presents the characteristics
of the various types of V-F circuits. Section 36 pre-
sents the characteristics of the various types of V-F
circuits. Section 37 presents the characteristics of the
various types of V-F circuits. Section 38 presents the
characteristics of the various types of V-F circuits. Sec-
tion 39 presents the characteristics of the various types
of V-F circuits. Section 40 presents the characteristics
of the various types of V-F circuits. Section 41 pre-
sents the characteristics of the various types of V-F
circuits. Section 42 presents the characteristics of the
various types of V-F circuits. Section 43 presents the
characteristics of the various types of V-F circuits. Sec-
tion 44 presents the characteristics of the various types
of V-F circuits. Section 45 presents the characteristics
of the various types of V-F circuits. Section 46 pre-
sents the characteristics of the various types of V-F
circuits. Section 47 presents the characteristics of the
various types of V-F circuits. Section 48 presents the
characteristics of the various types of V-F circuits. Sec-
tion 49 presents the characteristics of the various types
of V-F circuits. Section 50 presents the characteristics
of the various types of V-F circuits. Section 51 pre-
sents the characteristics of the various types of V-F
circuits. Section 52 presents the characteristics of the
various types of V-F circuits. Section 53 presents the
characteristics of the various types of V-F circuits. Sec-
tion 54 presents the characteristics of the various types
of V-F circuits. Section 55 presents the characteristics
of the various types of V-F circuits. Section 56 pre-
sents the characteristics of the various types of V-F
circuits. Section 57 presents the characteristics of the
various types of V-F circuits. Section 58 presents the
characteristics of the various types of V-F circuits. Sec-
tion 59 presents the characteristics of the various types
of V-F circuits. Section 60 presents the characteristics
of the various types of V-F circuits. Section 61 pre-
sents the characteristics of the various types of V-F
circuits. Section 62 presents the characteristics of the
various types of V-F circuits. Section 63 presents the
characteristics of the various types of V-F circuits. Sec-
tion 64 presents the characteristics of the various types
of V-F circuits. Section 65 presents the characteristics
of the various types of V-F circuits. Section 66 pre-
sents the characteristics of the various types of V-F
circuits. Section 67 presents the characteristics of the
various types of V-F circuits. Section 68 presents the
characteristics of the various types of V-F circuits. Sec-
tion 69 presents the characteristics of the various types
of V-F circuits. Section 70 presents the characteristics
of the various types of V-F circuits. Section 71 pre-
sents the characteristics of the various types of V-F
circuits. Section 72 presents the characteristics of the
various types of V-F circuits. Section 73 presents the
characteristics of the various types of V-F circuits. Sec-
tion 74 presents the characteristics of the various types
of V-F circuits. Section 75 presents the characteristics
of the various types of V-F circuits. Section 76 pre-
sents the characteristics of the various types of V-F
circuits. Section 77 presents the characteristics of the
various types of V-F circuits. Section 78 presents the
characteristics of the various types of V-F circuits. Sec-
tion 79 presents the characteristics of the various types
of V-F circuits. Section 80 presents the characteristics
of the various types of V-F circuits. Section 81 pre-
sents the characteristics of the various types of V-F
circuits. Section 82 presents the characteristics of the
various types of V-F circuits. Section 83 presents the
characteristics of the various types of V-F circuits. Sec-
tion 84 presents the characteristics of the various types
of V-F circuits. Section 85 presents the characteristics
of the various types of V-F circuits. Section 86 pre-
sents the characteristics of the various types of V-F
circuits. Section 87 presents the characteristics of the
various types of V-F circuits. Section 88 presents the
characteristics of the various types of V-F circuits. Sec-
tion 89 presents the characteristics of the various types
of V-F circuits. Section 90 presents the characteristics
of the various types of V-F circuits. Section 91 pre-
sents the characteristics of the various types of V-F
circuits. Section 92 presents the characteristics of the
various types of V-F circuits. Section 93 presents the
characteristics of the various types of V-F circuits. Sec-
tion 94 presents the characteristics of the various types
of V-F circuits. Section 95 presents the characteristics
of the various types of V-F circuits. Section 96 pre-
sents the characteristics of the various types of V-F
circuits. Section 97 presents the characteristics of the
various types of V-F circuits. Section 98 presents the
characteristics of the various types of V-F circuits. Sec-
tion 99 presents the characteristics of the various types
of V-F circuits. Section 100 presents the characteristics
of the various types of V-F circuits.

App note features V/F converters

The application note AN-14: *De-
signs for High Performance Volt-
age-to-Frequency Converters*, in-
vestigates circuit considerations
when designing V/F converters. It
also examines the advantages and
drawbacks of various approaches to
V/F conversion, and contains com-
plete schematics for the converters.

Linear Technology Corp, 1630
McCarthy Blvd, Milpitas, CA 95035.

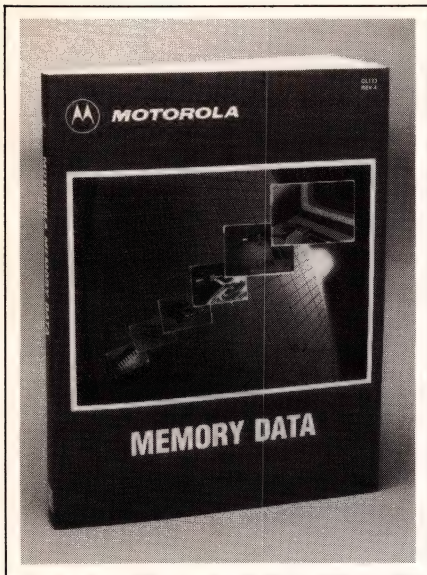
Circle No 445

Listing of MIL-STD and semicustom ICs

The vendor's product directory en-
compasses semicustom and radia-
tion-hardened ICs, as well as MIL-
STD-1553 and MIL-STD-1750
products. It describes each product,
lists specifications, and includes
block diagrams. Inside the cover
pages, the 24-pg catalog provides an
overview of the company and a list of
sales representatives.

UTMC, Communications Dept,
1575 Garden of the Gods Rd, Colo-
rado Springs, CO 80907.

Circle No 446



Memory data reference

The Memory Data Manual DL113, revision 4 presents specifications for the vendor's MOS static RAMs, dynamic RAMs, and PROMs, as well as CMOS and MECL memory technology and information about devices that meet military standards. A total of 12 chapters deals with support for system-level designs. The information includes pin assignments, packaging options, a list of basic features, electrical features, operating conditions, and timing diagram specifications. \$1.35 (25).

Motorola Inc., Technical Information Center, Box 52073, Phoenix, AZ 85072.

INQUIRE DIRECT

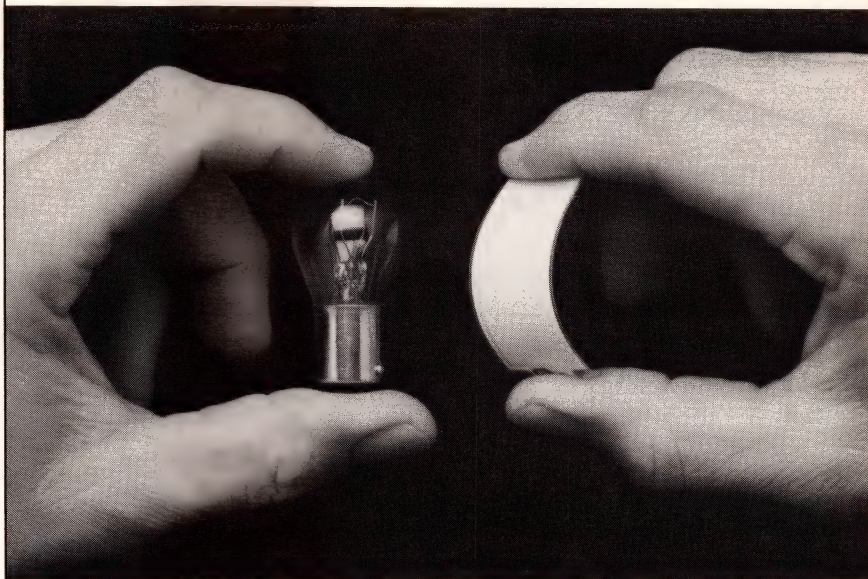
Public-domain software listing available

The 1988 Catalog of Public Domain PC Software (Shareware and User Supported Software) provides the classification of user-supported software, several drafting programs, and a 3D CAD program that has animation capabilities. The main body of programs covers 14 topics, including statistical process control, project management, surveying, flowcharting, heat load, and dBase III clone. Copying fee, \$3/disk (10).

Sector Systems Co Inc., 416 Ocean Ave, Marblehead, MA 01945.

INQUIRE DIRECT

PULL A LIGHT SWITCH.



FROM THIS... TO THIS.

Durel™ Electroluminescent (EL) lighting from Rogers eliminates the wasted space, energy, and heat of incandescent bulbs.

EL is light years ahead: No catastrophic failure. No filament to break. Immune to shock and vibration.

Uniform surface brightness and color: A single Durel lamp can replace a group of individual incandescent bulbs and costly light pipes.

Low power consumption: Typically less than 2mA per sq. in. at 115V, 400Hz. Ideal for battery power and low-current drain applications.

Thin: Nominal thickness of 0.024" (0.6mm) for space-efficiency.

Pliable: Flexibility permits bending to fit unique shapes.

High visibility in smoke/fog: Ideal for emergency lighting.

Call or write for information.



ROGERS

Rogers Corporation, Special Products Division
645 West 24th Street, Tempe, AZ 85282 (602) 967-0624

CIRCLE NO 54

DID YOU KNOW?

EDN is distributed
at every major
electronics/computer show in the
U.S., France, and Germany.

EDN

EDN's CHARTER

EDN is written for professionals in the electronics industry who design, or manage the design of, products ranging from circuits to systems.

EDN provides accurate, detailed, and useful information about new technologies, products, and design techniques.

EDN covers new and developing technologies to inform its readers of practical design matters that will be of concern to them at once or in the near future.

EDN covers new products

- that are immediately or imminently available for purchase
- that have technical data specified in enough detail to permit practical application
- for which accurate price information is available.

EDN provides specific "how to" design information that our readers can use immediately. From time to time, **EDN's** technical editors undertake special "hands-on" projects that demonstrate our commitment to readers' needs for useful information.

EDN is written by engineers for engineers.

EDN

275 Washington St
Newton, MA 02158
(617) 964-3030

F Warren Dickson
Vice President/Publisher
Newton, MA 02158
(617) 964-3030
Telex 940573
Diann Siegel, Assistant

Peter D Coley
VP/Associate Publisher/
Advertising Sales Director
Newton, MA 02158
(617) 964-3030
Ora Dunbar, Assistant/Sales Coordinator

NEW ENGLAND
John Bartlett, Regional Manager
Chris Platt, Regional Manager
199 Wells Ave
Newton, MA 02159
(617) 964-3730

STAMFORD 06904
George Isbell, Regional Manager
8 Stamford Forum, Box 10277
(203) 328-2580

NEW YORK, NY 10011
Daniel J Rowland, Regional Manager
249 West 17th St
New York, NY 10011
(212) 463-6419

PHILADELPHIA AREA
Steve Farkas, Regional Manager
487 Devon Park Dr
Suite 206
Wayne, PA 19087
(215) 293-1212

CHICAGO AREA
Clayton Ryder, Regional Manager
Randolph D King, Regional Manager
Cahners Plaza
1350 E Touhy Ave, Box 5080
Des Plaines, IL 60017
(312) 635-8800

DENVER 80206
John Huff, Regional Manager
44 Cook St
(303) 388-4511

DALLAS 75243
Don Ward, Regional Manager
9330 LBJ Freeway
Suite 1060
(214) 644-3683

SAN JOSE 95128
Walt Patstone, Regional Manager
Bill Klanke, Regional Manager
Philip J Branon, Regional Manager
James W Graham, Regional Manager
3031 Tisch Way, Suite 100
(408) 243-8838

LOS ANGELES 90064
Charles J Stillman, Jr
Regional Manager
12233 W Olympic Blvd
(213) 826-5818

**ORANGE COUNTY/
SAN DIEGO 92715**
Jim McErlan, Regional Manager
18818 Teller Ave, Suite 170
Irvine, CA
(714) 851-9422

PORTLAND, OREGON 97221
Pat Dakin, Regional Manager
Walt Patstone, Regional Manager
1750 SW Skyline Blvd, Box 6
(503) 297-3382

UNITED KINGDOM/BENELUX
Jan Dawson, Regional Manager
27 Paul St
London EC2A 4JU UK
44 01-628 7030
Telex: 914911; FAX: 01-628 5984

SCANDINAVIA
Stuart Smith
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FRANCE/ITALY/SPAIN
Alasdair Melville
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

WEST GERMANY/SWITZERLAND/AUSTRIA
Wolfgang Richter
Sudring 53
7240 Horb/Neckar
West Germany
49-7451-7828; TX: 765450

ISRAEL
Igal Elan
Elan Marketing Group
13 Haifa St, Box 33439
Tel-Aviv, Israel
Tel: 972-3-268020
TX: 341667

EASTERN BLOC
Uwe Kretschmar
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FAR EAST
Ed Schrader, General Manager
18818 Teller Ave, Suite 170
Irvine, CA 92715
(714) 851-9422; Telex: 183653

TOKYO 160
Kaoru Hara
Dynaco International Inc
Suite 1003, Sun-Palace Shinjuku
8-12-1 Nishishinjuku, Shinjuku-ku
Tokyo 160, Japan
Tel: (03) 366-8301
Telex: J2322609 DYNACO

TAIWAN
Acteam International
Marketing Corp
6F, No 43, Lane 13
Kwang Fu South Rd
Mailing Box 18-91
Taipei, Taiwan ROC
760-6209 or 760-6210
Telex: 29809
FAX: (02) 7604784

KOREA
BK International
Won Chang Bldg, 3rd Floor 26-3
Yoido-dong, Youngdungpo-ku
Seoul 150, Korea
Tel: 785-6665
Fax: 784-1915
Telex: K32487 BIZKOR

PRODUCT MART
Joanne Dorian, Manager
249 West 17th St
New York, NY 10011
(212) 463-6415

**CAREER OPPORTUNITIES/
CAREER NEWS**
Roberta Renard
National Sales Manager
103 Eisenhower Parkway
Roseland, NJ 07068
(201) 228-8602

Janet O Penn
Eastern Sales Manager
103 Eisenhower Parkway
Roseland, NJ 07068
(201) 228-8610

Western Sales Manager
18818 Teller Ave
Suite 170
Irvine, CA 92715
(714) 851-9422

María Cubas
Production Assistant
(201) 228-8608

Susan M Campanella, Advertising/Contracts Coordinator
Nan Coulter, Advertising/Contracts Coordinator
(617) 964-3030

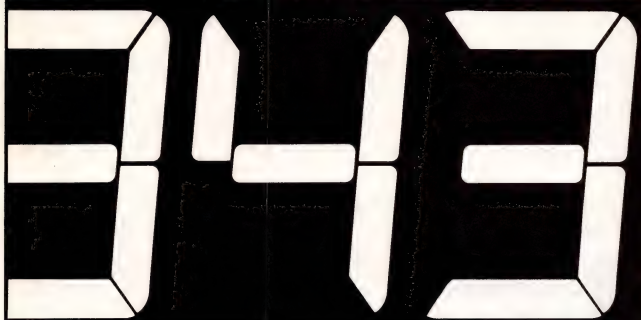
**William Platt, Sr, Vice President, Reed Publishing USA
Cahners Magazine Division**
Terry McDermott, President, Cahners Publishing Co
Frank Sibley, Group Vice President, Electronics/Computers
Tom Dellamaria, VP/Production & Manufacturing

Circulation
Denver, CO: (303) 388-4511
Sherri Gronli, Group Manager
Eric Schmierer, Manager

Reprints of EDN articles are available on a custom printing basis at reasonable prices in quantities of 500 or more. For an exact quote, contact Joanne R Westphal, Cahners Reprint Service, Cahners Plaza, 1350 E Touhy Ave, Box 5080, Des Plaines, IL 60018. Phone (312) 635-8800.

DAYLIGHT VISIBLE DISPLAYS

UP TO
1,000 FEET



Display sizes: 1½", 4", 6", 9", 12", 18" & 24"

ENERGY SAVING:

- ☐ Electromagnetic, bi-stable operation
- ☐ No bulbs to replace
- ☐ Maintenance-free
- ☐ Indication remains with power loss
- ☐ Power used only to change display
- ☐ Use indoors or outdoors
- ☐ -40°C to 75°C

IDEAL FOR:

- ☐ Instrumentation
- ☐ Industrial controls
- ☐ Timing Devices
- ☐ Toll Displays
- ☐ Metering Displays
- ☐ Production Line Displays

Call or write for full information

THE **STAYER** CO., INC.

P.O. Box H, Bay Shore, NY 11706
516-666-8000
TLX: 6711657
FAX: 516-666-8039

SIGNALEX®
HIGH VISIBILITY
DISPLAYS

CIRCLE NO 55

DC-DC CONVERTERS

To 25 Watts — From ERG —
Your DC PowerHouse!



• ERG DC-DC CONVERTERS.

Inputs from 5 to 48 VDC. Outputs from 5 VDC to 1500 VDC. Single, dual, center-tap (+/-) outputs. Regulated and unregulated. **Ask about our New Step-Down converters for battery-powered logic and other applications!**

• SMART FORCE™ INVERTERS FOR EL LAMPS!

Smart Force DC-AC Inverters extend the useful life of Electroluminescent lamps. Power EL to backlight LCDs and membrane switches, and more! **Ask about our New miniaturized P Package Inverters!**

Call today for complete product information and pricing:



Endicott Research Group, Inc.

2601 Wayne Street P.O. Box 269 Endicott, NY 13760
607-754-9187 TWX 510-252-0155

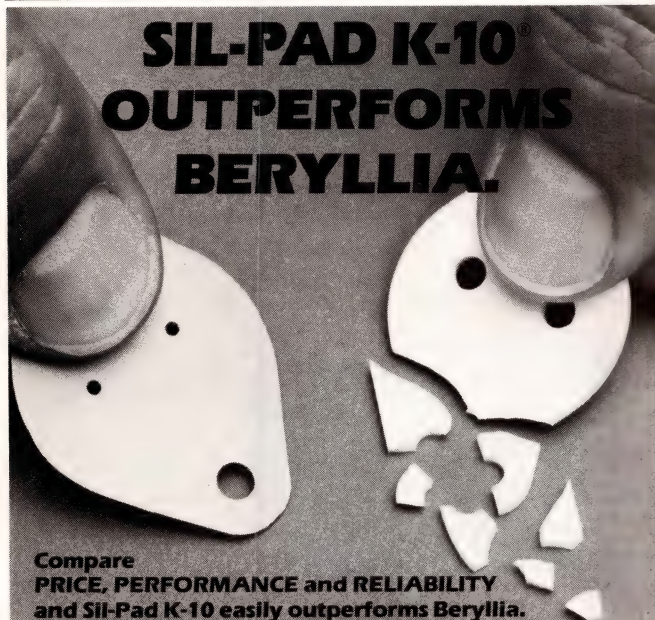
FAX: 607-754-9255

©1986 ERG, Inc.



CIRCLE NO 56

SIL-PAD K-10® OUTPERFORMS BERYLLIA.



Compare
PRICE, PERFORMANCE and RELIABILITY
and Sil-Pad K-10 easily outperforms Beryllia.

Sil-Pad K-10 combines DuPont's thermally filled Kapton® polyimide film and high performance Sil-Pad rubber to provide superior heat transfer, excellent cut-through resistance and dielectric strength. Yet Sil-Pad K-10 is a fraction of the cost of beryllia. Sil-Pad K-10 doesn't crack or fracture like fragile ceramic insulators. And, like all Sil-Pad products, Sil-Pad K-10 lowers your installed cost because it requires no grease.

Call Toll Free 1-800-328-3882 Today!

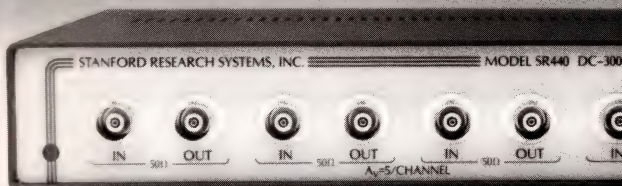
When Performance Counts
BERGQUIST

5300 Edina Industrial Blvd., Minneapolis, MN 55435, (612) 835-2322

CIRCLE NO 57

DC-300 MHz Amplifier:

\$950



- 4 independent channels
- Gain of 5/channel (cascaded gain: 625)
- 10 μ V/°C dc stability
- 25 μ V input noise

You can use the SR440 as a general purpose amplifier to improve the sensitivity of oscilloscopes, digitizers and spectrum analyzers. Power the SR440 with 120 or 240 V ac. NIM module format for dc operation also available: \$850 (model SR240).

Stanford Research Systems

1290 D Reamwood Avenue, Sunnyvale, CA 94089
TLX 706891 SRS UD, FAX 4087449049, TEL (408) 744-9040

CIRCLE NO 107

We've Invented the Future of Instrumentation Software . . . Twice.

With Words

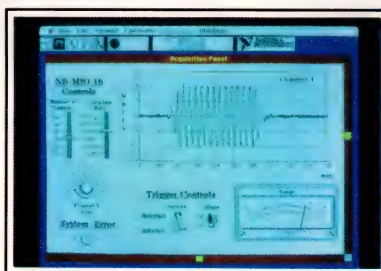
With Pictures

Acquisition

Integrated libraries for GPIB, RS-232, A/D-D/A-DIO plug-in cards, and modular instruments.



Intuitive character-based function panels that automatically generate source code.



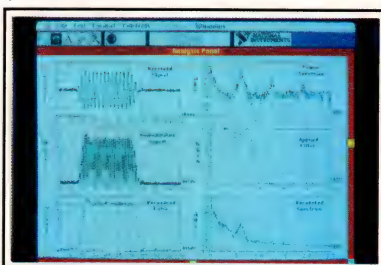
Front panel user interface with virtual instrument block diagram programming.

Analysis

Extensive libraries for data reduction, digital signal processing, and statistical analysis.



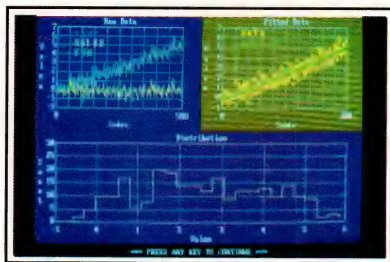
Over 100 analysis functions plus all the built-in functions of your language.



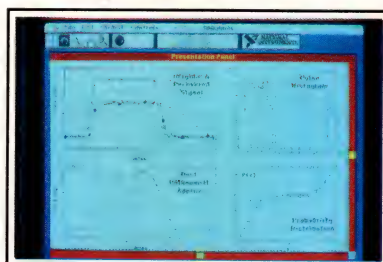
Over 250 icons for computation and analysis.

Presentation

Flexible high-performance graphics and report generation.



Extensive graphics support for CGA, EGA, MCGA, VGA, and Hercules.



Macintosh Desktop Publishing compatibility.

The Software is the Instrument

LabWindows™—
for the DOS-based PC and PS/2,
with Microsoft QuickBASIC or C.



**NATIONAL
INSTRUMENTS™**

12109 Technology Boulevard
Austin, Texas 78727-6204
800/531-4742 512/250-9119

LabVIEW®—
for the Apple Macintosh

DICK BURWEN

Mixing a love of engineering with a passion for hi-fi

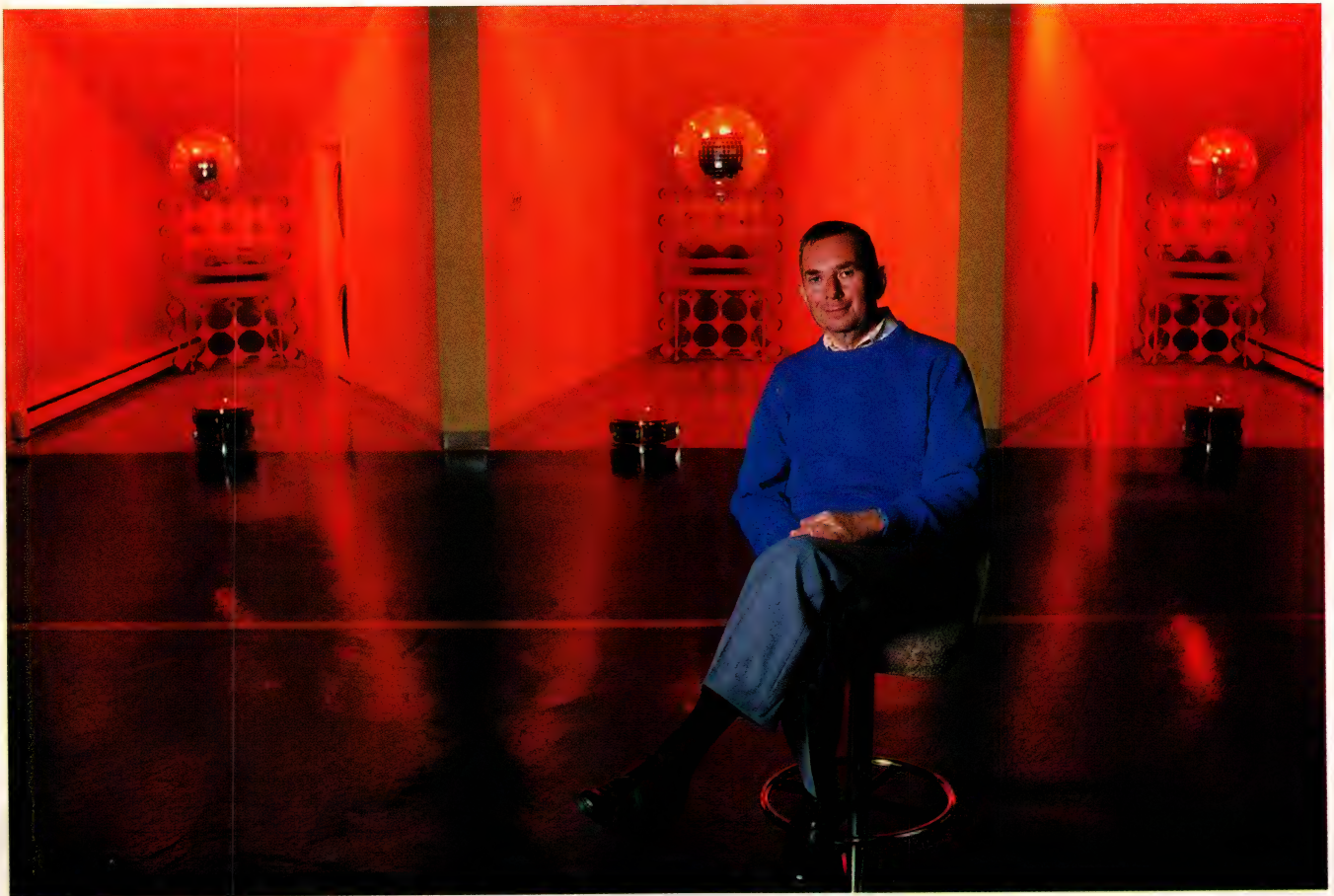
Deborah Asbrand, *Associate Editor*

Most independent consultants work out of their homes, and Dick Burwen is no exception. The analog-circuit designer's home contains office space, an extensive technical library, and a basement laboratory equipped with signal sources, measuring instruments, a temperature chamber, and thousands of electronic parts.

Burwen differs from some consultants, however, in that he likes to listen to music while he works and so has punctured one laboratory wall with five shoebox-size holes through which he can hear his stereo. His audio system, moreover, is not your average assemblage of components. For one thing, he designed and built all of the signal-processing equipment. For another,

the stereo employs 159 speakers, five giant speaker horns, and 17 stereo amplifiers. It also produces 20,000W of power. "I can really rattle the dishes in the kitchen," he says.

For the past 38 years, Burwen has successfully mixed his love of engineering with his passion for high-fidelity equipment. Having built a profitable consulting practice and



Webb Chapell

Burwen's quiet, inconspicuous manner belies a tremendous energy and capacity for work.

constructed an internationally acclaimed home listening/recording studio, he could easily rest on his laurels. Yet he keeps pushing the limits of analog-circuit design. His latest efforts include designing ultrahigh-efficiency switching-power amplifiers.

Shades of the career to come

Burwen's first move after college graduation foreshadowed the direction his career would eventually take. "When I got out of school, I retired for eight months," he says with a smile. "I went down to the basement to build a high-quality hi-fi set. It had an amp built into the base of the record player and it put out about 30W of power, which was remarkable in those days. But by

the time I finished it, I realized that the people who could afford it didn't care, and that the people who did care couldn't afford it. It was what today you'd call 'high-end' gear."

His first employer was Spencer-Kennedy Laboratories, a pioneer in cable television. He developed the company's wide-band television distribution system, which brought television to rural communities. In Barre, VT, Burwen supervised the installation of huge horns on poles that would receive signals from Boston, MA, 90 miles away.

Eleven years and several jobs later, Burwen concluded that the corporate environment was not for him. He had no interest in pursuing managerial positions and preferred to work on his own. "I was doing

consulting on the side when I decided I would see if I could get into the business full time," he says. "I took a vacation, made some phone calls, and six weeks later, I had three clients, so I quit my job."

In the 27 years since, Burwen has done much engineering. Stacked in the back of his basement are more than 100 3-in. binders filled with his project notes. He has worked on a fascinating array of assignments, from the development of a correlation receiving system for satellites to automotive ignition systems. For Lafayette, an early electronics-parts dealer, Burwen designed a 200W ultralow distortion amplifier. He also consulted on military and space-related projects and helped design instrumentation to measure the moon's magnetic field.

A tremendous energy

Burwen's quiet, inconspicuous manner belies a tremendous energy and capacity for work. He prefers to juggle three projects at once, he says, "because I don't like to work on one project for more than six or eight hours a day." Not surprisingly, he has no truck with small talk. Asked how he happens to come by such interesting and diverse assignments, he answers simply, "When you charge as much money as consultants do, people only bring you the interesting projects." And in response to a question about his instant success as a consultant—he's made a total of two "cold" calls to prospective clients—he shrugs, "Word travels."

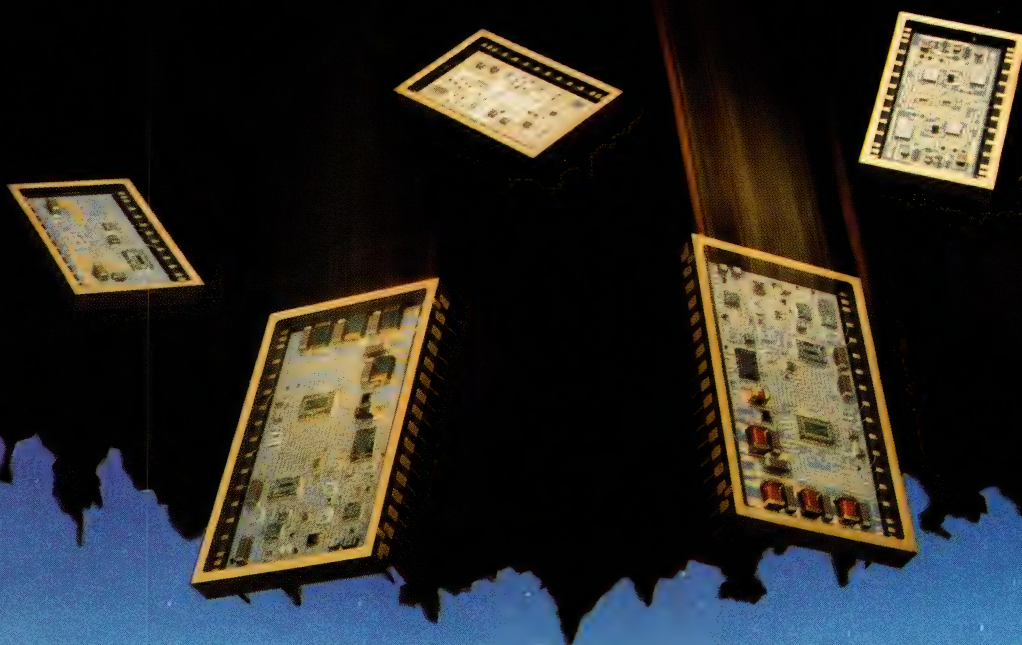
In 1965, with Matt Lorber and Ray Stata, Burwen founded Analog Devices, the Norwood, MA, manufacturer of integrated circuits. "I used to run around with a couple of op amps in my pocket to see if anyone wanted to buy them," he explains, with typical understatement. "I ran into Matt Lorber and Ray Stata who got into making them." It was Burwen who designed the company's first line of op amps and, later, of regulators and

Webb Chappell



An estimated 2500 op amps power the system, and Burwen once counted 1100 knobs on the many components.

SUB-MICROSECOND A/D CONVERTERS



Break through to new performance levels

DATEL's broad range of High Speed A/D converters give you the greatest choice available today from a single source. This combination of products coupled with DATEL's commitment to bringing you the fastest most precise and reliable A/D converters, will expand your design capability and enhance your system performance levels.

Speed up your designs with DATEL converters today.

Call or write for information on all DATEL data conversion products including complementary Track and Holds.

MODEL NUMBER	BITS OF RESOLUTION	CONVERSION TIME	THROUGHPUT (INCLUDING TRACK & HOLD AMPLIFIER)
ADC-500/-505/-508 ADC-B500/-B505 ADS-105/-106 ADS-21/-22	12	500-800 nSec	1.25-1.1 MHz 750 KHz 1.3/1.0 MHz
ADC-510/-515 ADS-115/-116 ADC-310	10	425 nSec 50 nSec	1.00 MHz
ADC-5101 ADC-815 ADC-303 ADC-304	8	900 nSec 700 nSec 10 nSec 50 nSec	
ADC-207	7	30 nSec	



CIRCLE NO 152

references. He also developed multipliers, chopper-stabilized amps, and some of the company's early ICs.

In 1972, Burwen started his own company, Ohmtec Corp, which manufactured consumer and professional audio equipment. He calls the move "the biggest mistake of my life" and dismisses the business, which folded in 1976, as "a bad marriage." KLH, however, bought an Ohmtec subsidiary, Burwen Labs, and continued to manufacture some of its noise-reduction equipment under the name KLH Burwen Research.

Whatever the consequences, Burwen has worked on his own terms ever since becoming a consultant. He has also carefully preserved his independence, retaining his consultant status even while he was actively involved in Analog Devices. Resolutely confident of his engineering skills, he has attached his name to that of almost every company he's started: Burwen Labs, Burwen Research, Burwen Studios, and Burwen Technology.

Burwen's engineering expertise has fueled his passion for hi-fi—though he has no ready answer as to where the roots of his hi-fi addiction lie. The most he can do is trace its history to his teenage interest in ham radios, which he was forced to abandon in favor of hi-fi equipment when amateur radio operation was banned during World War II.

World's best home stereo

In his youth, Burwen had assembled a 25-speaker stereo system powered by a 3W amp; however, in the early 1960s, when he and his young family moved into a small home of their own, the close quarters cramped his audio style. For 10 years, he'd been working on plans for a system that would generate not just better sound, but the world's best home-stereo audio. With that goal in mind, Burwen hired an architect to help him build a home that could accommodate such a project. Not surprisingly,

Burwen's meeting with the architect led to a new endeavor. "It turned out that the house would have cost more than I could afford, so I listened and watched the architect very carefully. I drew up my own plans and hired an engineer to do the framing of the structure. It worked out, fortunately."

Thoroughness is Burwen's hallmark. "Dick likes to do things in a big way," says Matt Lorber, who once again is Burwen's business partner, this time in Copley Controls, a Newton, MA, maker of dc servo amps. "He's a critical thinker, and he pursues things to an extent I've never seen before." The stereo system that Burwen built illustrates this point. (So does the security system that protects his two-story brick home. It, too, is a Burwen design.)

The listening/recording studio measures 48×28 ft. There are no windows in the concrete foundation, and the basement ceiling is constructed of extra-heavy plaster. The system's 159 speakers terminate in five giant horns that dominate the room. Each speaker horn is 8×8×13 ft. The walls of each horn are made of 4-in. filled cinderblock. The speakers have a dynamic range of more than 105 dB.

In addition to the speakers, the system employs 17 stereo amplifiers. Burwen designed the array and crossover system. The 8500W of amplifiers, together with the electronic crossover, give the system power equivalent to that of one 20,000W amplifier. An estimated 2500 op amps power the system, and Burwen says he once counted a total of 1100 knobs on the many components. The control panel is 7 ft tall, and the 5-ft, 9-in. Burwen has to stand on his toes to adjust the uppermost knobs.

The basement is also equipped for recording, and Burwen has acted as recording engineer for the dozen albums that have been made in his studio. "Dick is patient and intense," says Steven Schoenberg, a

local pianist who several years ago recorded an album of improvisational compositions at Burwen's studio. Indeed, Burwen's natural affability dissolves as soon as he begins to ready his system for a demonstration: Once the music starts to play, he stands looking downward, hands on his hips, listening to every note's acoustical travels.

The welcome invasion of digital

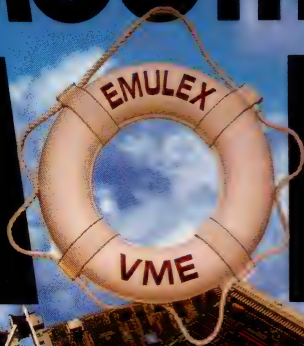
Aside from his home recording, Burwen produces master recordings for the Boston Philharmonic Orchestra, the Civic Symphony Orchestra of Boston, and the Banchetta Musicale, a chamber orchestra. Six years ago, he began recording with digital equipment, which he finds infinitely easier to use than the cumbersome analog apparatus he had previously used. "To record an 8 PM concert, I'd have to get to the hall at 2 PM to set up," he says. "I had my own noise-reduction equipment and analog tape recorders, about eight suitcases full of stuff. Now with three small suitcases that contain the main sound system and a complete spare, I make better recordings in 2-channel stereo digitally."

Although Boston boasts several fine recital halls, Burwen's favorite is the New England Conservatory of Music's 1100-seat Jordan Hall. While other local auditoriums are acoustically "dead" or "dry," he says, Jordan Hall is "nearly perfect." Burwen's attentive ears, however, detect subtle differences even within such near perfection. "There are only four perfect seats," he adds. "They're right under the edge of the balcony on either side of the aisle."

Although a frequent concert goer, Burwen is an engineer first and a music lover second. "At the symphony, I listen to the instruments, but especially to the sound of the hall. I spend half of my time there visualizing how I would record the music."

Burwen expends much of his professional energy on Copley Con-

EMULEX ALREADY HAS THE ONE THING VME SYSTEMS NEED FOR SMOOTH SAILING... MORE



To assure system designers and integrators of smooth sailing in the technologically advanced VME marketplace, Emulex has more of what's needed most. More designed-in quality . . . more VLSI expertise . . . more manufactured-in reliability . . . more OEM support . . . a more dependable supply source. More of everything that's important.

And our "MORE" philosophy applies to every member of our new family of products for the VMEbus.

Introducing:

- VT01 – a 9-track Pertec tape formatter controlling up to eight 1/2-inch tape drives. Tape densities can range from 800 to 6250bpi, tape speeds to 200ips.
- VM21 – a disk controller that can handle four ESDI disk drives with the highest transfer rates available – up to 20Mbps.
- VM31 – a disk controller for four SMD-E disk drives with transfer rates up to 3.0MB/sec and no penalty on performance.
- VS02 – a communications controller designed around a proprietary I/O processor that can

handle 16 asynchronous lines at 38.4Kbps simultaneously.

- VH01 – a SCSI host adapter based upon Emulex's own SCSI processor chip that supports synchronous transfer rates of 4.8MB/sec and asynchronous rates of 3.0MB/sec.

Let Emulex be more than your OEM supplier . . . think of us as your OEM partner. That means you can count on us for product quality and reliability, and for stability, capability and integrity. From initial design to final audit, Emulex is dedicated to meeting your needs . . . and MORE.

Call toll-free (800) EMULEX-3,
(714) 662-5600 in California.



I want to know MORE about VME products.

Name: _____

Company: _____

Address: _____

City: _____ State: _____

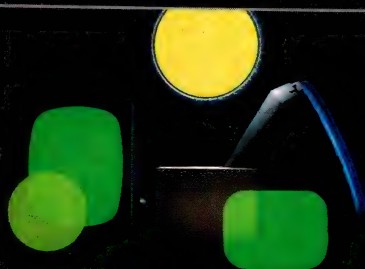
Zip: _____ Phone: _____

EDN051288

Emulex Corporation, 3545 Harbor Blvd., Costa Mesa, CA 92626

Regional Offices: Anaheim, CA (714) 385-1685 Atlanta, GA (404) 587-3610 Burlington, MA (617) 229-8880
Chicago, IL (312) 490-0050 Dublin, CA (415) 829-1170 Teaneck, NJ (201) 836-3717 Washington, DC (703) 264-0670
International Offices: Bracknell 344-484234 Munich 89-3608020 North Sydney 2-957-1669 Paris 134-65-9191 Tokyo 3-234-8951 Toronto (416) 673-1211
©1988 Emulex Corporation

CUSTOM X-Y MONITORS OFF-THE-SHELF



X-Y monitors for simulation, training, ATE, CAE/CAD/CAM or radar repeating. XKD can provide high performance XM-300 series monochrome stroke writers in a broad range of sizes, shapes, and phosphors without the usual long delivery times required for custom projects.

So if your application requires an X-Y monitor with high writing speed, fast settling time and excellent edge focus, and if you require special configurations promptly without extra charges, call Skip McLaughlin now at (408) 395-3700.



© XKD 1987

CIRCLE NO 58

PROFESSIONAL ISSUES

trols, the 5-year-old company he started with Lorber. As director of research, he designs all of the company's ultrahigh-efficiency switching power amps, which are used for, among other things, driving servo motors in motion-control systems and magnet coils in magnetic-resonance imaging systems. The switching technology allows Burwen to create amplifiers that produce from tens of watts to kilowatts in a volume of under 100 in³. The products' efficiency, which exceeds 95%, allows them to dissipate less than 10% of the power dissipated by conventional linear amps. The lower dissipation permits the systems that use the amps to have smaller power supplies and to run at lower temperatures, hence to exhibit higher reliability.

Designing such amps is a delicate, painstaking process. To be successful at it, designers must be keenly aware of the subtleties of circuit components and pc-board layouts. The inductance of a 1-in.-long etch run has been known to wreak havoc on switching-amplifier designs.

Burwen owns 25% of the company, but, true to form, retains a consultant's status vis a vis the firm. He also continues to operate his independent consulting firm, Burwen Technology, although he admits that his work for Copley Controls takes up most of his time. Unlike his earlier joint venture, he describes Copley Controls as "a good marriage." He still works out of his home laboratory, driving to Copley Controls' headquarters three times a week. The arrangement suits both Burwen and Lorber. "In the company environment, there are day-to-day matters that would be disturbing to Dick," says Lorber. "He wouldn't be able to devote his time to technical tasks."

Last year, tired of being "the only design engineer in the world without a computer," Burwen invested in a personal computer and bought software for stock-market trading,

word processing, and schematic drafting. He's an avid stock-market watcher and one of the first things he does on starting work each day at 6:30 AM is to log on to a subscription stock service.

But, betraying his analog background, he finds the long hours needed to set up the computer immensely frustrating. "Right now I'm trying to learn schematic drafting," he says, shaking his head. "I wasted so much time trying to get the machine started and configured. I spent six or eight hours a day getting my software installed and reading the books—but not doing anything useful."

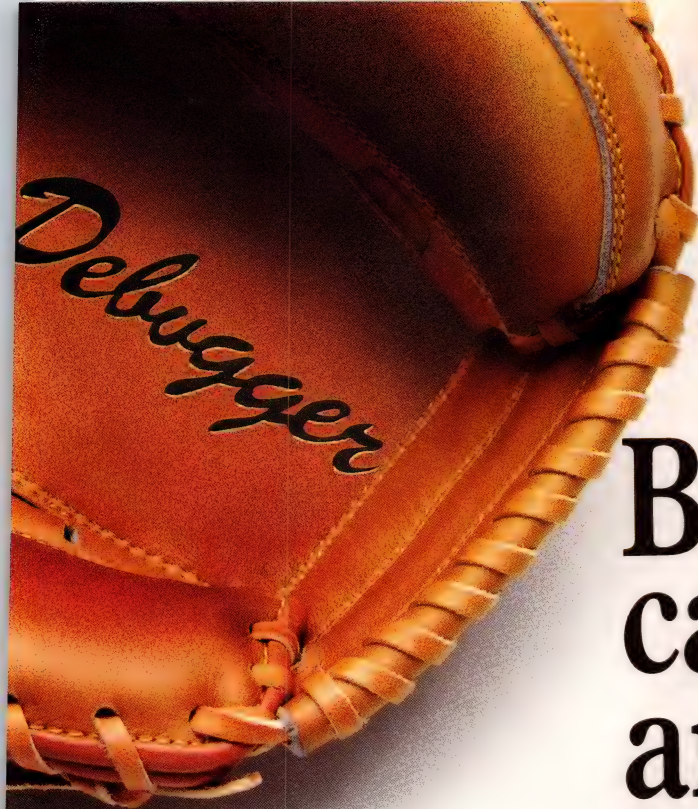
At 61, Burwen shows few signs of slowing down. For the past three months, he's been involved in projects that have frequently required his attention from early morning to past midnight. He says—unconvincingly—that he'd like to reduce the number of hours he works. Indeed, he ticks off a list of projects he has yet to complete. "See this pile of wires?" he says, pointing to a breadboard on a bench next to the electric organ. "It's a signal processor and an electronic replacement for the rotating speaker in the organ. It's been working like this for about 12 years. I don't know if I'm going to get to finish it or not."

When he does, he'll undoubtedly work to the accompaniment of a selection from his collection of "about six or eight hundred" recordings. "It's hard to work without music."

EDN

Article Interest Quotient
(Circle One)

High 515 Medium 516 Low 517



Best catcher in any league.

Check Out Our Performance

All players may cover the basics, but not many can play in our league. When making your first cut you should expect:

- No wait state emulation
- Source level and symbolic debugging
- File compatibility with HP, Intel, Tektronix, Motorola and more, including symbols
- IBM PC/AT and XT compatibility
- Variable trace depth to 4K steps with or without a target CPU break or reset
- Trace-and-go with data stored to disk
- A wide range of supported microprocessors
- Easy re-configuration and compatibility with earlier model hardware
- Dual processor capability
- Memory read and write protection with trace and break
- Menus or direct system commands with an on-line manual
- Complete assembler, linker, and library utilities
- Free software support services
- Parallel interface high-speed data transfer

What separates the pros from the players is performance, and Sophia's SA98 is a pro.

It's not enough to say you can play the game. You need that extra talent, and stamina to last. The SA98 is the hottest new pro in the league. It'll move you from 8- to 32-bit microprocessors with ease. Sophia Systems is one of the oldest and largest teams in the development system league.

Dedicated to MDS/ICE

Sophia Systems is a pro in the MDS and ICE field. Founded and dedicated to supplying the most advanced systems. Keeping the user in mind.

Try it Out

Add our new SA98 to your line-up. We're convinced we can catch your best curve. And do it in less time and in more detail than anyone else. Give us a try.

Call Toll-Free Today

1-800-824-9294 (U.S.)

1-800-824-6706 (CA)



U.S. & European Headquarters:

Sophia Systems, 3337 Kifer Road, Santa Clara, CA 95051 (408) 733-1571

Corporate Headquarters:

Sophia Systems Co., Ltd., NS Bldg. 8F, 2-4-1 Nishishinjuku, Shinjuku-ku, Tokyo 160 03-348-7000

©1988 Sophia Systems.

Sophia Systems is a registered trademark of Sophia Systems Co., Ltd.

ICE is a registered trademark of Intel Corporation.

MDS is a registered trademark of Mohawk Data Science Corporation.

IBM PC/AT and XT are registered trademarks of International Business Machines Corporation.

Sophia systems™

Dedicated to MDS/ICE Support

CAREER OPPORTUNITIES

1988 Editorial Calendar and Planning Guide

EDN

Editorial Emphasis

EDN News

Issue Date	Recruitment Deadline		
June 9	May 19	CAE, Analog ICs, Test & Measurement	Closing: May 29 Mailing: June 16
June 23	June 2	Data Communications, DSP, Components	
July 7	June 14	Product Showcase—Vol. I, Power Sources, Software	Closing: June 23 Mailing: July 14
July 21	June 30	Product Showcase—Vol. II, CAE, Test & Measurement	
Aug. 4	July 14	Sensors & Transducers, Analog ICs, Graphics	Closing: July 21 Mailing: Aug. 11
Aug. 18	July 28	Military Electronics Special Issue, Displays, Military ICs	
Sept. 1	Aug. 11	Instruments, Op Amps, Computers & Peripherals	Closing: Sept. 1 Mailing: Sept. 22
Sept. 15	Aug. 25	Data Acquisition, Data Communications, Digital ICs	
Sept. 29	Sept. 8	DSP, Graphics, Optoelectronics	Closing: Sept. 29 Mailing: Oct. 20
Oct. 13	Sept. 22	Test & Measurement Special Issue, Instruments, Computers & Peripherals	
Oct. 27	Oct. 6	CAE, Computers & Peripherals, Integrated Circuits, Wescon '88 Show Preview	

Call today for information:

East Coast: Janet O. Penn (201) 228-8610

West Coast: Ellen Sherwood (714) 851-9422

National: Roberta Renard (201) 228-8602

Senior Software & System Engineers

**HEARTBEAT HEARD AROUND THE WORLD...
THERE'S NEVER BEEN A
BETTER TIME TO CHOOSE GE**

Innovation! Technical Leadership! It's happening at GE Medical Systems. Join a new team and engineering revolution in cardiac ultrasound as well as our expanding global efforts in CT, Magnetic Resonance and X-ray. Outstanding careers for "Thinkers & Doers" with mid-project leader levels of computer science/engineering experience now open at Milwaukee, WI headquarters.

Software & Systems—Ultrasound:

RealTime software design environment including C, VRTX, UNIX, 68010 micro-processor, digital signal processing, image analysis, color graphics, in-depth hardware diagnostics, creation/management of system development tools. Systems position(s) desire ultrasound, sonar or radar experience.

Software & Systems—Multi-Modality:

Software design environment involves C, UNIX PACS, INTEL, hi-performance networks, hi-resolution display systems, large scale archive system and data bases.

Our employee benefits package befits an industry leader. Please send your resume with salary history in strict confidence, to: EDN W416, GE Medical Systems, P.O. Box 414, Milwaukee, WI 53201



GE MEDICAL SYSTEMS

An Equal Opportunity Employer

FLORIDA WANTS TOP TALENT!

DoD communications systems developers in Florida need top engineers with 10+ years experience in:

Program Management
RF & Digital Systems Engineering
VLSI/VHSIC
Signal processing
Phased arrays
Spaceborne power supplies
Avionics/space packaging
CAD systems

All candidates need current DoD clearance and BS or higher degree.

Karl Frederick (EDN 5)

235 Cocoa Avenue
Indialantic, Florida 32903

ELECTRONICS • AEROSPACE NATIONWIDE S30-80K

Opportunities for Engineers & Professionals in Defense/Aerospace and Commercial Industries. Send Resume to:

JACK PORTER ASSOCIATES, INC.

385 Front St. N., Issaquah, WA 98027
(206)455-4928

All fees paid by client companies.

At Compaq, a first-place finish is only the beginning.

When you're setting the pace, you don't stop to rest.

Our people have taken us farther, faster than any company in history. Now Compaq is the industry leader in 80386-based personal computers for business. In 1987, we became the fastest company to reach \$1 billion in annual sales. And our sprint to the Fortune 500 turned in a record time as well.

But getting out in front wasn't easy. Staying there is even tougher. It takes the careful planning and hard work of a team of talented professionals.

Compaq people are individual achievers. At the same time, they participate as part of a team. As a Compaq professional, you'll hit the ground running. Your voice will be heard and you'll share in the big picture.

Surface Mount Technology Engineers:

Challenge your surface mount technology experience in design, manufacturing, quality, reliability, and sustaining engineering. You'll have a hand in the process with your BS in Engineering and two years' experience in a high-volume manufacturing environment.

Systems Architects:

Design new products by investigating and evaluating system compatibility and performance of design alternatives and new technologies. You'll develop hardware compatibility tests and performance analysis tools.

Qualify with a BSEE, MSEE preferred, and three years' hardware background with a knowledge of microprocessor-based systems software. In addition, experience with CPUs/memory/bus architecture, numeric co-processors, file subsystems, network/communications, graphic subsystems and state machines is required.

Systems Software Engineers:

Evaluate, design and develop firmware, operating systems, device drivers and utility software for PC systems. You'll need a BSCS, BSEE or equivalent degree with four years' related experience in PC software development, 8086/286/386 Assembly/"C" language programming in MS-DOS, OS/2 and/or UNIX/XENIX operating systems.

Software Quality Assurance Engineers:

Put your design and development expertise to the test improving structural software. You'll help increase the reliability of PC systems and operating systems software. With a BSEE/BSCS and five years' software quality assurance or testing experience, the challenge is yours. Knowledge of "C" and 8086/286/386 Assembly language is essential.

Systems Support Analysts:

Put third party software/hardware through the paces to analyze Compaq products' level of compatibility and ensure compliance with industry standards. Your technical support and trend monitoring of new third party products put you on the forefront of systems development. You'll need four years' related experience in the microcomputer industry and a thorough knowledge of systems software, operating systems, languages and third party products.

You'll need a BS/BA in Engineering, Computer Science or related field. In addition, you need three years' experience in microsystems application and operations with expertise in micro-to-mainframe communications, multi-user systems software, multi-tasking environments, networking, and hardware for graphics, microprocessors and PCs.

Microprocessor Logic and ASIC Design Engineers:

Your skills in high-speed logic design and/or microprocessor system design put you out in front. You'll use flow charts and timing diagrams for digital design and analysis. Your experience should include vendor libraries, test vector generation, simulation checkout and TTL emulators for gate/array standard cell design. Familiarity with CAE systems used in logic design, and documentation is also necessary. Five years' experience should accompany your BSEE or related degree. An MSEE is preferred.

Failure Analysis Engineers:

As a Compaq Failure Analysis Engineer, you'll take the lead assuring quality and performance of Compaq products. Bring your BS in Electrical Engineering or Materials Engineering and three years' experience in failure analysis using SEM/EDS with you.

Can you run with the leader?

You won't know until you try. At Compaq, the freedom of our unique corporate environment helps foster the greatest creativity and highest levels of personal satisfaction. A career with Compaq means you'll have room to run. You'll play an important role and be recognized for your accomplishments.

Please submit your resume, salary requirements and the position for which you wish to be considered to:

Compaq Computer Corporation, Dept. EDN512-MW, P.O. Box 692000, Houston, Texas 77269-2000. Compaq is an affirmative action employer, m/f/h/v.

©1988 Compaq Computer Corporation. All rights reserved.

The Compaq logo, featuring the word "COMPAQ" in a bold, italicized, sans-serif font.

Analog and Digital Design Engineers

Design the Home of the Future

Square D has always been a leader in the electrical industry since its beginning. Today, we're still innovating unique products, competing in market after market and branching out into new field of technology.

Currently we are participating in the Smart House Venture, a consortium of many companies working together to develop the automated home of the future.

We are seeking creative individuals with experience in the development of high volume electronic and electromechanical products to join our growing electronic design team. These challenging positions will provide the successful candidate the opportunity to be responsible for product development from the market driven concept phase to high volume production.

We currently seek an individual that can combine their analog, digital, and software talents to create products for the home of the future. We also seek an individual with strong analog and magnetic experience.

To qualify for these positions, the successful candidates should have a BSEE degree and 3 to 5 years applicable experience in the design and production of high volume electronic products.

SQUARE D offers competitive compensation, generous benefits and a stimulating technical and career environment. You'll also enjoy the comfortable, affordable way of life in Cedar Rapids, Iowa, a mid-size city set in the beautiful Midwest heartland.

For consideration, send your resume in confidence to:

Lisa J. Hugnet
Technical Recruiter



SQUARE D COMPANY

3700 Sixth Street S.W. • Cedar Rapids, IA 52406

An Equal Opportunity Employer M/F/H



HAMS

- **LAB SUPERVISOR**
- **ASSISTANT TECHNICAL EDITORS**

Positions Available At National Headquarters

- **Require BSEE or Equivalent**
- **Lab/Test Procedures Experience**
- **Design/Supervisory Experience**
- **Demonstrated Writing Ability/PC Use**

Send resume and letter telling us why you are the person for one of these jobs to:

**American Radio
Relay League, Inc.**

Technical Department Manager
225 Main Street
Newington, CT 06111

No Phone Calls Please
an equal opportunity employer (M/F)



ARE YOUR IDEAS AHEAD OF OUR TIME?

Stonehenge, one of the most famous of all the classical megalith monuments, has long been an important part of the popular and scientific imagination. Its origin has been the cause of speculation for years, as scientists try to discern who had the intellect and ingenuity to create a celestial observatory of such astronomical significance and exactness.

What is clearly understood and shared these 4,000 years later is man's unceasing fascination with the heavens and his need to explore them for a better understanding of his place in time and space.

The construction of Stonehenge required remarkable genius and ability — and so will the endeavors we have planned at General Dynamics Space Systems Division.

You can now be a part of our exciting time in history. Your ideas and accomplishments could be chronicled for future generations to study as hallmarks of a brilliant epoch in space exploration.

We currently have opportunities available in the areas listed below for individuals with a technical degree or the equivalent combination of formal education and related experience. Government or aerospace industry background is preferred. If you are interested in one or more of these areas, please send your resume to: Professional Staffing, GENERAL DYNAMICS SPACE SYSTEMS DIVISION, MZ C2-7143-I207, P.O. Box 85990, San Diego, CA 92138. (Opportunities also exist in Huntsville, AL and Harlingen, TX.)



STRUCTURAL DESIGN

- Advanced Composite Structures
- Tank Structures
- Adapters
- Fairings
- Materials & Processes
- Pre-Design
- Liaison
- Super Conducting Magnets
- Drawing Checkers

STRESS ANALYSIS

- Hand Analysis
- Finite Element Modeling
- Structural Test Support
- CAE
- Methods
- Advanced Composites

TEST & EVALUATION

THERMAL/FLUIDS ANALYSIS

- Systems Modeling
- Space Environments
- Propulsion
- Cryogenics

AVIONICS

- EMI/EMC
- Electrical Power
- Instrumentation
- RF Systems
- Parts Engineering
- Harness Design/Installation
- Liaison
- Analog/Digital Circuit Design
- Avionics Systems
- Mechanical Packaging
- Control Systems
- Guidance & Navigation

SYSTEMS

- Systems Requirements
- Systems Safety
- Environmental Engineering
- Security Engineer
- Software

DYNAMICS/ANALYSIS

- Launch Vehicle Transient Load
- Environmental Dynamics
- Acoustics
- Jettison Trajectory
- IRAD & CRAD
- CAE

FLUID SYSTEMS DESIGN

- Pneumatic
- Hydraulic
- Propulsion
- Cryogenics

GENERAL DYNAMICS
Space Systems Division

Equal Opportunity Employer/Principals Only

EDN Databank

Professional Profile

Announcing a new placement service for professional engineers!

To help you advance your career, Placement Services, Ltd. has formed the EDN Databank. What is the Databank? It is a computerized system of matching qualified candidates with positions that meet the applicant's professional needs and desires. What are the advantages of this new service?

- It's absolutely free. There are no fees or charges.

- The computer never forgets. When your type of job comes up, it remembers you're qualified.
- Service is nationwide. You'll be considered for openings across the U.S. by PSL and its affiliated offices.
- Your identity is protected. Your resume is carefully screened to be sure it will not be sent to your company or parent organization.

- Your background and career objectives will periodically be reviewed with you by a PSL professional placement person.

We hope you're happy in your current position. At the same time, chances are there is an ideal job you'd prefer if you know about it.

That's why it makes sense for you to register with the EDN Databank. To do so, just mail the completed form below, along with a copy of your resume, to: Placement Services, Ltd., Inc.

IDENTITY

Name _____ Parent Company _____
Home Address: _____ Your division or subsidiary: _____
City _____ State: _____ Zip: _____ Location (City, State) _____
Home Phone (include area code): _____ Business Phone if O.K. to use: _____

PRESENT OR MOST RECENT EMPLOYER

EDUCATION

Degrees (List)

Major Field	GPA	Year Degree Earned	College or University

POSITION DESIRED

EXPERIENCE

Present or Most Recent Position From: _____ To: _____ Title: _____

Duties and Accomplishments: _____ Industry of Current Employer: _____

Reason for Change: _____

PREVIOUS POSITION:

Job Title: _____

Employer: _____ From: _____ To: _____ City: _____ State: _____

Division: _____ Type of Industry: _____ Salary: _____

Duties and Accomplishments: _____

COMPENSATION/PERSONAL INFORMATION

Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation
Date Available	I Will Travel ☐ Light ☐ Moderate ☐ Heavy			☐ I own my home. How long? _____ ☐ I rent my home/apt. ☐		
☐ Employed ☐ Self-Employed ☐ Unemployed		☐ Married ☐ Single		Height _____ Weight _____		
Level of Security Clearance		☐ U.S. Citizen ☐ Non-U.S. Citizen		My identity may be released to: ☐ Any employer ☐ All but present employer		
☐ WILL RELOCATE ☐ WILL NOT RELOCATE ☐ OTHER _____						

EDN Databank

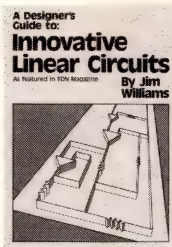
A DIVISION OF PLACEMENT SERVICES LTD., INC.

265 S. Main Street, Akron, OH 44308 216/762-0279

A Designer's Guide to Linear Circuits

Volume I:

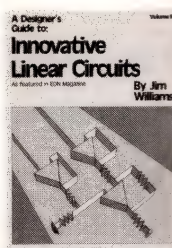
This original, 186-page collection by Jim Williams offers a wealth of analog design information. It includes practical and efficient ways to use op amps, comparators, data converters, and other analog ICs, and discusses the theories behind all the design techniques presented.



A Designer's Guide to Linear Circuits

Volume II:

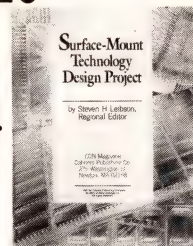
The reader response to Volume I was so positive that we're offering Jim Williams' latest analog design articles—from 1983 to 1986—in an all-new Volume II. An even bigger collection than before, Volume II is still written in the language of working engineers, but now covers the newest and more complex circuits and systems in 266 pages.



You can buy the volumes separately, or as a set. Either way, you'll have all the latest information on the most sophisticated linear ICs, from Jim Williams, one of the country's foremost linear-circuit designers.

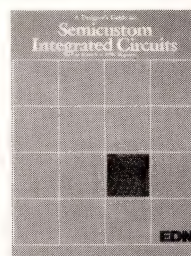
Surface-Mount Technology Design Project

NEW!



Now you can order copies of EDN magazine's exclusive hands-on surface-mount design series. This 48-page, four-color reprint follows the progress of EDN editor Steve Leibson as he designs a 2 MByte memory board using surface-mount technology. Leibson takes you from his initial concept through to the finished working product, and includes typical problems you might encounter and objectively reports about both good and bad design decisions made along the way.

A Designer's Guide to Semicustom Integrated Circuits



Learn how to design a semicustom IC with this reprint. Based on EDN's own design experience, this nine-chapter booklet outlines the complete procedure used to design, fabricate, and test EDN 1, a chip with a 1200 equivalent-gate complexity. You'll not only learn the steps to take when creating ICs, but also the design/cost analyses and vendor-interface methods that lead to successful semicustom chips.

✂ Mail coupon to: EDN Reprints, EDN Magazine, Cahners Building, 275 Washington Street, Newton, MA 02158-1630

Please send the following:

— copies of *A Designer's Guide to Innovative Linear Circuits*.

Volume I

☐ \$14.95 (UPS)

☐ \$19.95 (non-USA)

Volume II

☐ \$18.95 (UPS)

☐ \$23.95 (non-USA)

— copies of the **combined set** of *A Designer's Guide to Innovative Linear Circuits Volumes I & II*

☐ \$29.95 (UPS)

☐ \$39.95 (non-USA)

— copies of *Surface-Mount Design Project*

☐ \$7.95 (UPS)

☐ \$10.95 (non-USA)

— copies of *A Designer's Guide to Semicustom Integrated Circuits*

☐ \$6.95 (UPS)

☐ \$10.95 (non-USA)

Foreign checks must be drawn on a US Bank, issued in US currency.

Please print clearly. This is your mailing label.

Name _____

Title _____

Company _____

Address _____

City _____ State _____ Zip _____

EDN051288

*Check or money order made out to **EDN REPRINTS** must accompany each order. No COD. Mass. residents add 5% sales tax.

We're overwhelmed with your response

To our semiannual contest in the January 7, 1988 issue of EDN. Thousands of you took the time to tell us which three ads in that issue were your favorites. But only one of you is the proud winner of a new camcorder. He's Koray Wilkes, an engineer at Boeing Military Airplane Company.

Our congratulations to him and to the ten lucky winners of \$25 gift certificates. And our thanks to all of you who made this the most overwhelming EDN contest ever.

Keep a special lookout for the August 4, 1988 issue of EDN, when you'll have another chance to participate and win!

EDN

ADVERTISERS INDEX

Abbott Transistor Labs Inc	238	Gould/AMI Semiconductors*	148-149	Rapid Systems	163
ABC-Taiwan Electronics Corp	284	GP Electronics	280	RLM Research	285
ACCEL Technologies Inc	283	Grayhill Inc	236	Robotrol	285
ACDC Electronics	250	GTEK Inc	281	Rogers Corp	283, 293
Acheson Colloids Co	281	Hall-Mark	211	Rohde & Schwarz**	55
Acopian Corp	245	Hamilton Avnet Electronics	233	Rohm Corp*	150
Advanced Micro Devices	12-13, 70-71	Harris Semiconductor Products	168	Samsung Semiconductor	252-253
Advin Systems	282	Heurikon Corp	263, 265	Samtec Inc	74
Aeroflex Laboratories Inc	214	Hewlett-Packard Co	18-19, 105, 152, 177	Schlumberger	134-135
American Automation	240	Hitachi America Ltd*	96-97	Seagate Technology	206
Ametek Inc	42	Honeywell	269	Seeq Technology Inc	33
Amlan Inc	95	Houston Instrument	110-111	SGS-Thomson Microelectronics*	54-55
Amoco Laser Co	264	Illinois Capacitor	274	Shih Hsin Precision	292
AMP	68-69	Inmos Corp*	166-167	Siemens	90, 109
Amperex Electronic Corp*	288	Intel Corp	187	Siemens AG**	84-85, 150-151
Analog Design Tools Inc	175	International Rectifier	C3	Silicon Systems Inc	92, 93
Analog Devices Inc	82-83, 235	Intusoft	285	Siliconix Inc	4
Apollo Computer	50-51	I/O Tech	261	Single Board Solutions	283
Applied Data Systems	280	Ironics	131	Sipex Corp-Hybrid Systems	287
Applied Microsystems Corp	14-15	ITT Pomona Electronics	218	Sophia Systems Co Ltd	303
Ashling Microsystems Ltd**	288	John Fluke		Sorensen Co	257
Atron	65	Manufacturing Co Inc	6, 159, 161	Spectrum Software	273
Bayer AG**	96-97	KEC Electronics Inc	289	Sprague Electric Co	79
B&C Microsystems	280, 282, 283	Keithley Instruments	255	Standard Logic	32
Bergquist Co	295	Knurrag	262	Standard Telephon and Radio	198-199
BP Microsystems	281	Kuan Hsi Electronics	282	Stanford Research Systems Inc	295
Brooktree Corp	226, 227	Logical Devices Inc	279	Statek	292
Burndy Corp	37	LSI Logic Corp	28-29	The Staver Co Inc	295
Burr-Brown Corp	230	Marconi Electronic Devices	249, 251	System Industries	146-147
Bussman	267	Marconi Instruments*	151	Tatum Labs	162
Bytek Corp	281	Marshall	248	TEAC Corp**	6
CAD Software Inc	281	Matra Harris Semiconducteurs	130	Tektronix Inc	8, 38-39, 237, 239, 243, 258-259, 270-271, 290
CADdy Corp	254	Matrox Electronic Systems Ltd	204	Teledyne Semiconductor	114-115, 178-179, 312
California Eastern Labs Inc	276	Maxell	197	Teradyne Inc	30-31
Capital Equipment Corp	284	Maxtor	16-17	Termiflex Corp	234
Catalyst Research	190	Memocom	279	Thomas Electronics Inc	232
Cherry Electrical		Mentor Graphics Corp	10-11	Toshiba America Inc	112-113
Products Inc	212-213, 279	Meta Software	260	TRW/LSI Products Div	23
Chomerics Inc	200	Metrabyte	283	Uniform Tubes Inc	34
Coilcraft	228	Micro Networks	216-217	Universal Cross—Assemblers	282
Comair Rotron Inc	34	MicroCASE	20	VCH International	279
Communications Specialists Inc	280	Microstar Laboratories	95	Vector	286
Crystal Semiconductor	106-107	Microswitch	188-189	Vectron Laboratories Inc	266
Cybernetic Micro Systems	291	Mini-Circuits Laboratories	26-27, 209, 314	Wave Mate Inc	283
Cypress Semiconductor	52	Moli Energy Ltd	95	Wavetek	3
Daisy Systems Corp	46-47	Motorola Microcomputer Div	72	Wickmann Werke	130
Dasoft Design Systems Inc	281	National Instruments	296	Winpoint Electric Corp	285
Data I/O Corp	C4	National Semiconductor Corp	56-57, 80-81	WinSystems Inc	283
Datel	299	NCR Microelectronics Div	60	Wintek Corp	282, 285
Deltrol Controls	280	NDK	180	Xilinx	132-133
Deltron Inc	232	Nicolet	25	XKD Corp	302
Design Computation Inc	285	Nohau Corp	279	Zericon	284
Digital Equipment Corp*	84-85	Nova Tran Corp	272	Zilog Inc	89
Digital Media Inc	285	OKI Semiconductor	40-41	Zippy Shin Juih Corp	284
Eagle Magnetic	281	Omaton Inc	283		
EF Johnson Co	281	Optimal Technology	285		
EH Titchener & Co	281	Orion Instruments	66-67		
Eldre Components Inc	284	Otto Controls	44		
Electrochem	195	Patton & Patton	284		
Electro-Mechanics	282	Performance Semiconductor Corp	43		
Electronic Solutions	86	Phihong Enterprise Co Ltd**	54		
Emulation Technology Inc	285	Philips Test &			
Endicott Research Group	295	Measuring Instruments Inc**	149, 159		
Engineering Tutorial Software	280	Pioneer Magnetics	275		
Everest Electronic Equipment Inc	278	Pittman	44		
Ferroxcube	229	Planar Systems	58		
Fujitsu Computer Products Group	77	Plessey Microsystems	277		
Fujitsu Limited**	161	Potter & Brumfield	246-247		
Galil Motion Control Inc	284	Power General	291		
GE Plastics	45	Powertec Inc	92		
GE/RCA Intersil		Precision Monolithics Inc	C2		
Semiconductors	48-49, 98-99, 164-165	Qua Tech Inc	280, 282, 284		
GIMIX Inc	280	Quantum Corp	136-137		
Gould Inc, Design & Test Systems Div	59	RAF Electronic Hardware Inc	162		

Recruitment Advertising . 304-309

American Radio Relay
 Carl Frederick Square D Co
 Compaq Computers
 General Dynamics Space Systems
 General Electric
 Jack Porter and Associates

*Advertiser in US edition

**Advertiser in International edition

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

Need More Design Time?



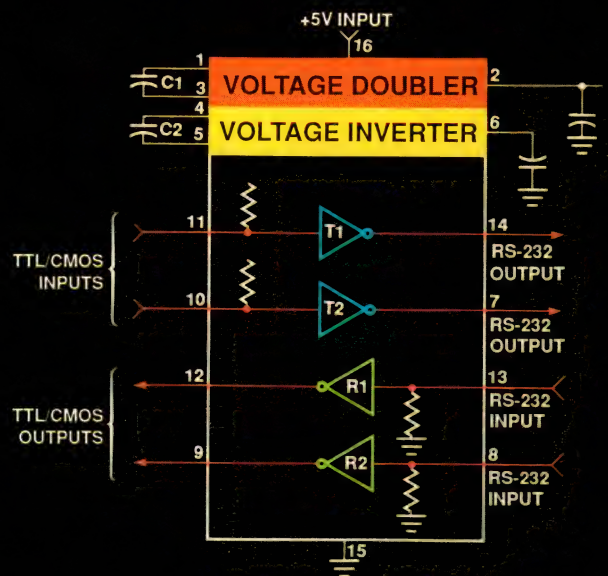
Let us design your **RS-232** interface then. Eliminate 1488/1489 chip sets and complex analog power supply voltage level converter design. **RS-232** ports are a snap to produce with our **TSC232** receiver/transmitter pair and power supply converter integrated circuit. Your 5V logic power supply is converted to ± 10 power supply levels. We've met the standard so you can concentrate on non-standard designs.

All **RS-232** specifications are met and external receiver input protection components are unnecessary for ± 30 V inputs. Reduce your RFI levels with the slew rate limited **TSC232** dual output transmitters.

CMOS technology cuts your data transmission errors and maximizes noise immunity through efficient +5V to ± 10 V supply conversion. The low power requirements are a natural for battery applications.

Samples and production volume available now. Commercial, industrial, military and military/883 devices. Select from DIP or surface mount package options.

The **TSC232** is compatible electrically with the MAX232. Now you can **CHOOSE TELEDYNE FIRST** and benefit from our 25 year history of dependable service and quality production.



TELEDYNE
SEMICONDUCTOR

1-800-888-9966

415-968-9241

1300 Terra Bella Avenue
P.O. Box 7267
Mountain View, CA 94039-7267
TWX: 910/379-6494
FAX: 415/967-1590

LOOKING AHEAD

EDITED BY CYNTHIA B RETTIG

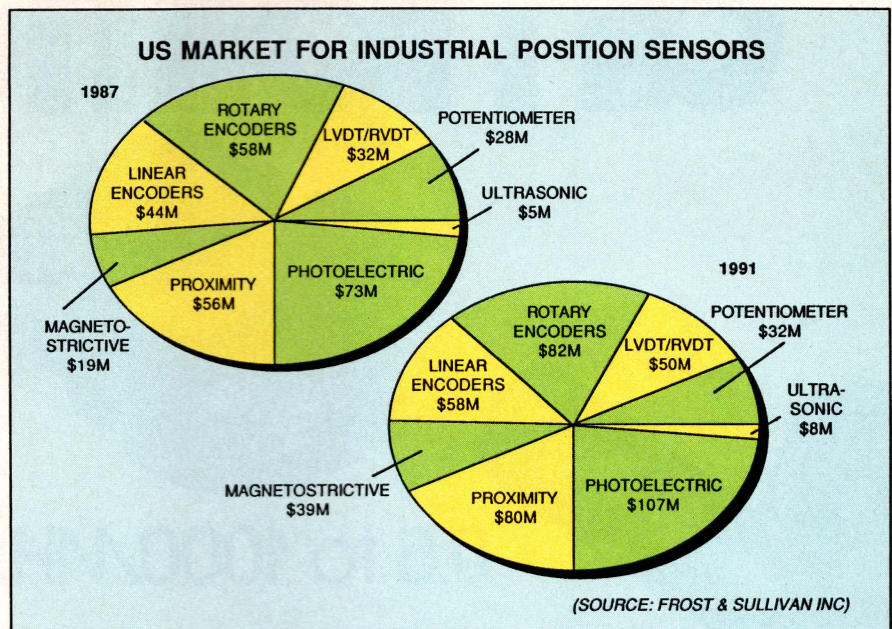
US position-sensor market to grow steadily through '91

While different segments of the US market for industrial position sensors are expected to grow at strikingly varying rates over the next few years, the overall market prediction points to a healthy, steady growth through 1991, according to Frost & Sullivan (New York, NY). Last year, the US market grossed \$315 million; by 1991, the total figure should reach \$456 million. For onboard automotive sensors, the research data indicates that, in spite of declining sales for autos made in the US, this market segment will nevertheless grow because of expected increases in the sale of light trucks.

Magnetostrictive sensors are expected to boast an 18% average annual growth through 1991: Sales in that year are expected to reach \$39 million, up close to 100% from the 1987 figure. This type of sensor takes advantage of the characteristic of some ferromagnetic materials (for example, iron, nickel, cobalt, and manganese) by changing size in response to a magnetic field. To date, the largest application for magnetostrictive sensors has been in electrohydraulic actuators, where the sensors can be embedded within the actuator piston for absolute-value positioning.

With primary uses in automated material handling and packaging machinery, photoelectric sensors should reach a total of \$107 million in sales by 1991. Manufacturers are finding these devices useful not just in measuring proximity or displacement but also in counting and identifying. Photoelectric sensors can also transmit information to other systems by sending logic-level data via a modulating LED light beam.

Among the newer devices, ultrasonic sensors will rise rapidly in industrial applications, from \$5 million in 1987 to \$8 million at the end of the forecast period. Although



their price tag—about \$250 each in small quantities—remains a real deterrent for more general use, ultrasonic devices have some big advantages. Most important, devices

based on that technology remain unaffected by harsh environments, where even photoelectric devices can falter.

Consider associated costs of nonimpact printers

The costs involved in owning a non-impact printer include not only the price of the printer itself but also charges for service, consumables, paper, and electricity, advises CAP International Inc (Marshfield, MA). In fact, purchasers should consider specific applications as well as average monthly print volumes when trying to decide which kind of non-impact printer suits their needs.

An analysis of the leading non-impact printer types reveals four primary operating environments.

The first, the centralized data-processing facility, typically requires the production of more than 1M copies per month. Printers employed in such a facility run as fast or faster than 80 pages per minute and cost over \$300,000.

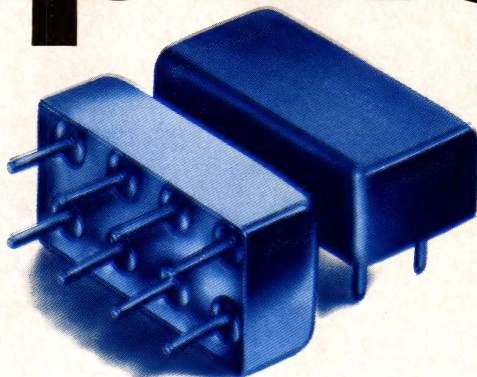
The second primary operating environment, a distributed data-processing site, is linked to or controlled by a central facility. Generally,

printers operating in such an environment produce 100,000 to 500,000 copies per month and operate at speeds between 35 and 80 pages per minute. They range in price from \$15,000 to \$140,000.

The third type of environment is an office cluster serving either a single department or a group that produces similar work. Nonimpact printers used in this environment produce between 5000 and 50,000 copies per month and run at speeds between 10 and 35 pages per minute. They cost between \$3000 and \$35,000.

The personal workstation that has five or fewer users is the final category of primary operating environment. A printer used as part of such a workstation produces between 5000 and 3000 copies per month and produces fewer than 10 pages per minute. Prices range from \$1400 to \$8000.

rugged plug-in amplifiers



0.5 to 1000 MHz from \$13⁹⁵ (5 to 24 qty)

Tough enough to meet full MIL-specs, capable of operating over a wide -55° to $+100^{\circ}\text{C}$ temperature range, in a rugged package... that's Mini-Circuits' new MAN-amplifier series. The MAN-amplifier's tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won't break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 500MHz and 0.5 to 1000MHz, and NF as low as 2.8dB.

Prices start at only \$13.95, **including** screening, thermal shock -55°C to $+100^{\circ}\text{C}$, fine and gross leak, and burn-in for 96 hours at 100°C under normal operating voltage and current.

Internally the MAN amplifiers consist of two stages, including coupling capacitors. A designer's delight, with all components self-contained. Just connect to a dc supply voltage and get up to 28dB gain with +9dBm output.

The new MAN-amplifier series...
another Mini-Circuits' price/performance breakthrough.

MODEL	FREQ. RANGE (MHz)	GAIN dB		MAX. OUT/PWR† dBm	NF dB (typ)	DC PWR 12V, mA	PRICE \$ ea. (5-24)
	f_L to f_U	min	flatness††				
MAN-1	0.5-500	28	1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28	1.0	8	2.8	60	15.95
◇MAN-1HLN	10-500	10	0.8	15	3.7	70	15.95

†† Midband $10f_L$ to $f_{U/2}$, $\pm 0.5\text{dB}$

† IdB Gain Compression

◇ Case Height 0.3 in.

Max input power (no damage) +15dBm; VSWR in/out 1.8:1 max.

finding new ways ...
setting higher standards

Mini-Circuits

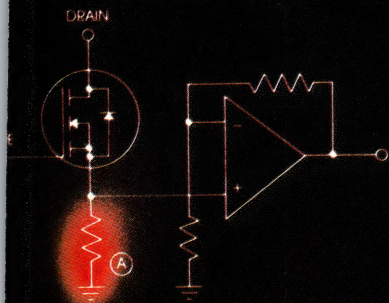
A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

CIRCLE NO 156

C118 REV. B

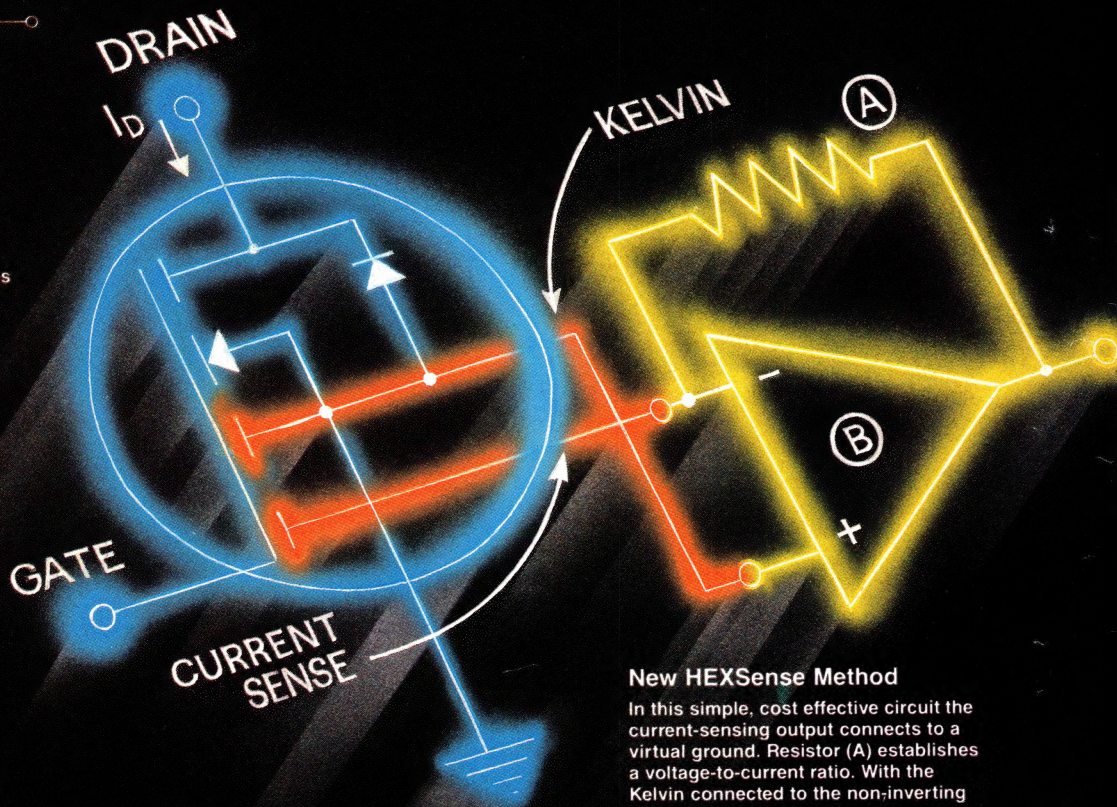
Now! HEXSense™

makes today's current-sensing obsolete.



Old Method

This circuit uses a fractional value resistor (A) to measure current, causing a voltage drop which increases power losses. Its parasitic inductance also slows down switching speed. To offset these losses, a lower $R_{DS(ON)}$ power MOSFET may be used, increasing circuit cost.

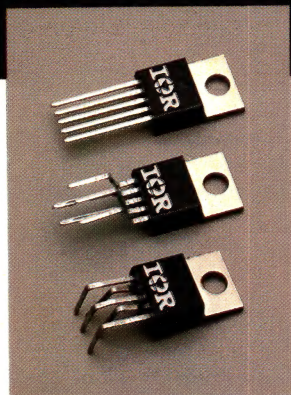


New HEXSense Method

In this simple, cost effective circuit the current-sensing output connects to a virtual ground. Resistor (A) establishes a voltage-to-current ratio. With the Kelvin connected to the non-inverting input of (B), a highly accurate current-sense results.

HEXSense offers 5-pin lead forms for vertical and horizontal pcb mounting.

HEXFET and HEXSense are trademarks of International Rectifier.



HEXSense, a new HEXFET power MOSFET with built-in current-sensing, reduces component count and design time — making conventional current-measuring methods obsolete.

Your circuit designs are simplified in less board space. Power and voltage losses disappear. Accuracy and bandwidth increase. In the end, your system performs better, more reliably.

It's all made possible by our HEXFET power MOSFET's superior quality, faster switching speed, built-in avalanche withstand capability, and now, current-sensing for control and protection.

In short, now you can design easier and more accurate, cost effective current-sensing circuits with the quality choice in power MOSFETs. Call (213) 607-8842 for technical data. Today.

Number 1
in power MOSFETs

International Rectifier

WORLD HEADQUARTERS: 233 KANSAS ST., EL SEGUNDO, CA 90245, U.S.A. (213) 772-2000. TWX 910-348-6291, TELEX 472-0403
EUROPEAN HEADQUARTERS: HURST GREEN, OXTED, SURREY RH8 9BB, ENGLAND TELEPHONE (088 33) 3215 4231, TELEX 95219

Power MOSFETs • CMOS Power ICs • Commercial/Custom Power Packages • Schottkys
Rectifiers • Thyristors (SCRs) • Diode Bridges • Molded Circuits • Assemblies

CIRCLE NO 120



$\text{Count} = (\text{Count} + 1) \&$
 $(\text{Count} < 13)$

AUTOMATIC SCHEMATIC.

FUTUREDESIGNER: DRAW LESS. DESIGN MORE.

Introducing FutureDesigner™ — the only advanced design entry workstation that lets you describe your circuit in compact, high-level terms and create more complex designs faster. FutureDesigner's flexible, new techniques encourage creativity and experimentation, helping you produce innovative products quickly and more accurately.

MULTIPLE DESIGN ENTRY MODES FOR SPEED AND FLEXIBILITY.

Describe your circuit with any combination of structural and behavioral representations. Use schematics to enter the structural portions of the design, such as data paths in a memory array. For portions easier to describe behaviorally, like sequencers or decoders, simply enter equations, truth tables or state diagrams using on-screen input forms.

ADVANCED DESIGN VERIFICATION HELPS YOU GET IT RIGHT THE FIRST TIME.

For the behavioral portions of your design, use FutureDesigner as a "what if" tool to try different design approaches. Immediately verify that your circuit works as you intended. For the structural portions, design check tools detect and help you correct connectivity and other common design errors. Together these features significantly shorten the design iteration cycle.

LOGIC SYNTHESIS CONVERTS YOUR EQUATIONS INTO SCHEMATICS.

Once you've entered equations, state diagrams or truth tables, FutureDesigner's logic synthesizer eliminates redundant circuitry and optimizes your design for size/speed trade-offs. FutureDesigner is the only design entry workstation that will then automatically produce the correct schematics and integrate them with the total structural design.

MORE CHOICES IN TECHNOLOGIES, VENDORS AND SYSTEMS.

FutureDesigner is technology independent. Choose the most convenient mix of TTL, PLDs, gate arrays or other ASICs from a wide range of semiconductor manufacturers. You can easily migrate from one technology to another without redesign.

FutureDesigner output is an industry standard, widely accepted by engineering service bureaus and semiconductor vendors. You'll also have access to both FutureNet® and other CAD systems for simulation and PCB layout.

Call us today and learn how a FutureDesigner workstation gives you the flexibility and accuracy to design innovative products faster.

1-800-247-5700
Dept. 121

Data I/O Corporation 10525 Willows Road N.E., P.O. Box 97046, Redmond, WA 98073-9746, U.S.A. (206) 881-6444/Telex 15-2167
FutureNet 9310 Topanga Canyon Boulevard, Chatsworth, CA 91311-7528 (818) 700-0691/Telex 910-494-2681
Data I/O Canada 6725 Airport Road, Suite 302, Mississauga, Ontario L4V 1V2 (416) 678-0761/06968133
Data I/O Europe World Trade Center, Strawinskylaan 633, 1077 XX Amsterdam, The Netherlands (20) 622866/Telex 16616 DATIO NL
Data I/O Japan Sumitomoseimei Higashishinbashi Bldg., 8F, 2-1-7, Higashi-Shinbashi, Minato-ku, Tokyo 105, Japan (03) 432-6991/Telex 2522685 DATAIO J

©1987 Data I/O Corporation.

CIRCLE NO 121

FutureNet
A Data I/O Company